

28. You are asked to perform an antenatal ultrasound examination and note that the placenta has an unusual morphology. You see an additional lobule, which is separate from the main bulk of the placenta. What is this variant of placental morphology known as?

- A. Circumvallate placenta.
- B. Bilobed placenta.
- C. Placenta membranacea.
- D. Succenturiate placenta.
- E. Placenta accreta.

29. You are the interventional radiology fellow in your hospital. A nephrologist has asked you for an opinion on four patients they feel require renal arterial intervention. Patient A is a 68-year-old male who has had a catheter angiogram which showed a 60% narrowing in the right renal artery. This patient has refractory hypertension. Patient B is a 42-year-old female, also with refractory hypertension. She has had an MR angiogram, which has shown a number of stenoses, with intervening mild aneurysm formation, in the proximal right renal artery. Patient C is a 72-year-old female with impaired renal function, who underwent captopril renal scintigraphy. On the baseline study, there was a similar appearance of the kidneys. On the captopril study, there was a differential split of renal function of 15% between the right and left kidney, with a decrease of time to peak activity of 320 seconds. The final patient D had a renal Doppler ultrasound, which showed a biphasic flow pattern in the segmental arteries, with a slow upstroke. Which of these patients has significant atherosclerotic renal artery stenosis?

- A. Patients A and B.
- B. Patients C and D.
- C. Patients A, C, and D.
- D. Patients B, C, and D.
- E. All of them.

30. A 36-year-old male patient presents with abdominal pain. He has a history of hypertension and obesity. A CT of abdomen reveals a 6-cm right adrenal mass, which shows heterogeneous but peripheral enhancement, necrosis, and some calcification. There is early invasion of the IVC. The left adrenal gland is atrophied. What is the most likely diagnosis?

- A. Neuroblastoma.
- B. Adrenal cortical carcinoma.
- C. Myelolipoma.
- D. Adrenal adenoma.
- E. Pheochromocytoma.

31. A 30-year-old male with a thyroid nodule is referred for an ultrasound guided FNA. The FNA cytology reveals medullary thyroid carcinoma, which is treated by total thyroidectomy. The following year he undergoes a CTPA examination, which shows a small nodule in the thyroid region. Which of the following serum markers is useful in assessing recurrence?
- CA 19-9.
 - Calcitonin.
 - CA 125.
 - Thyroglobulin.
 - Calcium.
32. A 24-year-old woman presents to the symptomatic breast clinic with a palpable left-sided breast lesion. There is no family history of breast cancer. Clinical examination reveals a smooth, relatively mobile 2-cm lesion within the left upper quadrant. Ultrasound depicts a well-defined oval hypoechoic lesion with an echogenic capsule following the tissue planes. No malignant features are present. The patient states that she has a phobia of needles. What should be the next step in this patient's management?
- Reassurance and discharge with advice.
 - Correlation with mammography.
 - Ultrasound guided core biopsy.
 - Ultrasound guided FNA.
 - Referral for MRI.
33. A 40-year-old man has an ultrasound examination of the abdomen for epigastric pain. The examination is normal apart for an isoechoic 'mass' at the midpole of the left kidney. You suspect this may be a normal variant, such as a prominent column of Bertin. You recommend a CT scan of kidneys to confirm this. Which phase of a CT renal tract examination would best show this variant?
- Unenhanced scan.
 - Cortico-medullary phase.
 - Nephrographic phase.
 - Early excretory (3-minute) phase.
 - Late excretory (10-minute) phase.

37. A 49-year-old woman presents with a rapidly enlarging left-sided breast mass. A large, firm, non-tender discrete mass is noted on clinical examination with overlying skin ulceration. Mammography reveals a 7-cm multilobulated soft tissue density mass in the left upper quadrant. On ultrasound the mass is solid with cystic areas. Posterior acoustic enhancement is demonstrated. What is the most likely diagnosis?

- Adenoid cystic carcinoma.
- Fibromatosis.
- Granular cell tumour.
- Phyllodes tumour.
- Melanoma metastasis.

38. A 50-year-old man attends his GP feeling generally lethargic. The GP organizes blood tests and these reveal renal impairment. A subsequent ultrasound examination shows bilateral hydronephrosis without obvious cause. A CT scan of the abdomen then demonstrates that the hydronephrosis is secondary to bilateral ureteric obstruction from abnormal retroperitoneal soft tissue, intimately related to the aorta and IVC. Which of the following features on CT would suggest that the soft tissue is more likely due to retroperitoneal fibrosis, rather than a malignant cause?

- Nodular contour to the soft tissue.
- Contrast enhancement of the soft tissue.
- More severe hydronephrosis in the kidneys.
- Close application of the soft tissue to the adjacent vertebrae.
- Soft-tissue extension above and below the level of the renal hila.

39. A 73-year-old male patient is referred from the urologists with a new diagnosis of prostate cancer. He is having an MRI scan to help stage the tumour. The patient reports that he has had a trans-rectal ultrasound (TRUS) biopsy done, but cannot remember when and the date is not on the form. The following information is present on the request form: 'The tumour is not palpable on digital rectal examination (DRE). The prostate specific antigen (PSA) is 2.4. One of four biopsies was positive and the Gleason score from this was 5; When you do the MRI scan there is low signal in the peripheral zone on the left. There is also low signal on the right, which extends into the seminal vesicles. The images of the pelvis and para-aortic region do not show any evidence of lymphadenopathy. Which of these options would you choose for your report?

- Repeat scan in 4 weeks.
- T1 disease.
- T2a disease.
- T2c disease.
- T3b disease.

34. You are consulted about a 24-year-old male patient who is day 3 following a blind right-sided renal biopsy, which diagnosed glomerulonephritis. He has been well until today, when he developed acute right flank pain and haematuria. The urologists asked for an IVP prior to assessing the patient. They feel this showed an absent kidney, but on the 15- and 20-minute images, you feel you can detect a faint nephrogram that is slightly more pronounced on the 20-minute image. Given your suspicions about the cause, which of the following would be the least likely to contribute to the diagnosis?

- Ultrasound.
- MRI with GE sequences of the right kidney.
- MRI with SE sequences of the right kidney.
- Arterial phase CT abdomen.
- Portal venous phase CT abdomen.

35. A 58-year-old smoker presents with haemoptysis and chest pain. A CT of chest confirms a lung carcinoma. While reporting the CT you notice that there is enlargement of the right adrenal gland. The patient has already left the department, but by chance is due to have an MRI scan of lumbar spine at a nearby institution the following morning. Due to time constraints, they can only fit in one sequence to image the adrenal glands. Which one sequence is of most use in further characterizing the adrenal abnormalities?

- T2WI.
- STIR.
- Axial T1WI with fat saturation.
- In- and out-of-phase T1WI.
- DWI.

36. A 40-year-old male with a history of haematuria undergoes CT urography. Initial non-contrast scan demonstrates right-sided medullary nephrocalcinosis. Following intravenous contrast administration, a striated 'painted brush' appearance of the renal medulla is noted. The left kidney is unremarkable. What is the diagnosis?

- Hyperparathyroidism.
- Renal tubular acidosis.
- Medullary sponge kidney.
- Sarcoidosis.
- Multiple myeloma.

40. A 45-year-old woman presents with anorexia and loss of weight. A CT of abdomen reveals bilateral non-calcified ovarian masses, but no ascites and no significant pelvic lymphadenopathy or peritoneal disease. Serum alpha fetoprotein, beta human chorionic gonadotrophin (β -HCG), and CA-125 are normal. The gynaecology team request an MRI of pelvis. This reveals that both ovaries are enlarged, the left more than the right. Bilateral cystic masses with low signal on T2WI/intermediate signal T1WI with solid portions are demonstrated. Gadolinium-enhanced T1WI with fat saturation reveals marked enhancement of these solid components and septa. What is the most likely diagnosis?

- A. Krukenberg tumours.
- B. Sertoli-Leydig tumours.
- C. Dysgerminomas.
- D. Fibromas.
- E. Endodermal sinus tumours.

41. A 54-year-old female patient presents with anaemia and haematuria. A CT of abdomen confirms renal cell carcinoma of the right kidney, but there is also enlargement of the right adrenal gland. Which of the following CT characteristics is most consistent with a benign adrenal adenoma?

- A. A pre-contrast attenuation of 50.
- B. An immediate post-contrast attenuation of 50.
- C. A relative percentage washout (RPV) of 60%.
- D. Lesion size of 50 mm.
- E. Heterogeneity of the lesion.

42. A 35-year-old female presents with a history of menorrhagia. MRI of pelvis demonstrates a fibroid uterus for which treatment with high-intensity focused ultrasound (HIFU) is proposed. What is the principle mechanism of action of HIFU?

- A. Coagulation necrosis.
- B. Apoptosis.
- C. Cavitation.
- D. Microstreaming.
- E. Radiation forces.

43. A 60-year-old woman presents with a palpable lump in her right breast. Her recent screening mammogram 6 months previously was negative. Clinical examination reveals a subtle mass in the right lower quadrant. Which of the following mammographic findings is the most common in invasive lobular carcinoma (ILC)?

- A. Spiculated mass.
- B. Architectural distortion.
- C. Microcalcification.
- D. Nipple retraction.
- E. Skin thickening.

44. You are asked to assess a 24-year-old woman with TVUS. The patient presents with lower abdominal cramps and is approximately 5 weeks post last menstrual period (LMP). Her pulse and blood pressure are normal. β -HCG levels suggest that the patient is pregnant. On TVUS, no adnexal mass or free fluid is seen. Which of the following findings would you expect to see in the uterus to confirm that the patient does not have an ectopic pregnancy?
- Pseudogestational sac.
 - Normal endometrium.
 - Trilaminar endometrium.
 - Double decidual sac sign.
 - Thin-walled decidual cyst.
45. A 56-year-old male patient has presented to the urologists with a PSA of 17 ng/ml. He does not have a mass palpable on DRE. Two separate TRUS investigations, with a total of eight biopsies, have failed to yield a tissue diagnosis. The urologists have asked you to carry out an MRI to help guide their future biopsies. As is routine in these difficult cases, magnetic resonance spectroscopy (MRS) is carried out on suspicious areas to provide extra information. The MRI identifies an area of low signal in the anterior peripheral zone. This reveals an elevated choline and creatine peak, and a reduced citrate peak. Which of these features is suggestive of carcinoma?
- Elevated choline.
 - Reduced polyamine peak.
 - Reduced citrate peak.
 - None of them, MRS is only sensitive in the transition zone.
 - All of them.
46. A 64-year-old patient is referred for a CT of abdomen 10 days post laparotomy for a right hemicolectomy for colonic adenocarcinoma. His post-operative course is initially uneventful, but the request form states that over the last 2 days he has developed pyrexia and today his inflammatory markers are markedly raised, he is 'septic' and unwell. The surgeons suspect a perforation or anastomotic leak, but you find no significant free fluid or air. There is marked bilateral enhancement of the adrenal glands, which are normal in size. The remainder of the abdominal viscera are unremarkable and the IVC and aorta are normal in calibre. There is marked consolidation at both lung bases. What is the significance of the appearance of the adrenal glands?
- Hypovolaemic shock.
 - Phaeochromocytoma.
 - Hypervascular metastases.
 - Addisonian crisis secondary to tuberculous adrenitis.
 - Adrenal hyperplasia as a response to the recent surgery.

47. A 46-year-old female with pressure symptoms related to uterine fibroids is referred for fibroid embolization. Which of the following complications is the patient at increased risk of?

- A. Uterine sepsis.
- B. Fibroid passage.
- C. Fibroid regrowth.
- D. Ovarian dysfunction.
- E. Hysterectomy.

48. A 28-year-old primiparous woman has been breastfeeding for the past 3 months. She is admitted surgically complaining of warmth and pain in her right breast associated with swinging fever. A 3 x 2 cm inhomogenous, hypoechoic abscess within the right lower inner quadrant is identified on ultrasound. How should this patient be managed?

- A. 6 weeks' antibiotic therapy followed by repeat ultrasound.
- B. Ultrasound guided needle aspiration.
- C. Ultrasound guided catheter drainage.
- D. Surgical incision and drainage.
- E. Analgesia and advice to stop breastfeeding.

49. A 60-year-old man has an unenhanced CT scan of renal tracts for suspected right renal colic. The examination is normal apart from an exophytic rounded lesion at the midpole of the left kidney, which is denser than adjacent renal parenchyma. You elect to perform an intravenous contrast-enhanced examination in the nephrographic phase to further evaluate this lesion. Which of the following Hounsfield attenuation values would be most appropriate if this lesion is benign?

- A. 20 pre-contrast attenuation, 30 post-contrast attenuation.
- B. 30 pre-contrast attenuation, 60 post-contrast attenuation.
- C. 40 pre-contrast attenuation, 50 post-contrast attenuation.
- D. 50 pre-contrast attenuation, 80 post-contrast attenuation.
- E. 60 pre-contrast attenuation, 70 post-contrast attenuation.
- F. 70 pre-contrast attenuation, 100 post-contrast attenuation.

50. A 24-year-old male patient presents to the A&E department with a history of severe episodic right-sided loin pain, radiating to the groin. He has no history of previous renal calculi. A low-dose non-contrast CT of the renal tracts shows a calculus in the distal right ureter, adjacent to the vesico-ureteric junction. The calculus measures 7 mm in diameter. The patient has a horseshoe kidney. There is stranding in the peri-nephric fat and around the right ureter. The density of the calculus is measured to be 1500 HU. Which of these observations is least likely to have relevance to this patient's treatment?

- A. Site of the calculus.
- B. Size of the calculus.
- C. Perinephric and periretoretic stranding.
- D. Density of the calculus.
- E. Horseshoe kidney.

51. A 60-year-old woman presents with pelvic pain. An MRI reveals multiple large areas of well-circumscribed, predominantly homogenous low T2WI and low/intermediate T1WI signal within the myometrium. There are also a number of peritoneal nodules demonstrated. What is the most likely diagnosis?

- A. Endometriosis.
- B. Adenomyosis.
- C. Uterine leiomyomas.
- D. Endometrial carcinoma.
- E. Metastases to the uterus.

52. A 2-day-old male neonate with a right-sided abdominal mass is referred for ultrasound of abdomen. Ultrasound demonstrates an enlarged right kidney containing multiple non-communicating cysts of varying size with little normal parenchyma. What is the most common associated abnormality of the contra-lateral kidney?

- A. Ectopic ureter.
- B. Pelvi-ureteric junction obstruction.
- C. Vesico-ureteric reflux.
- D. Renal hypoplasia.
- E. Renal aplasia.

53. A 36-year-old labourer working on a building site falls 15 feet from scaffolding on his back onto a wheelbarrow. He is catheterized in the resuscitation room and is noted to have gross haematuria. Which of the following CT findings are consistent with a grade 4 renal injury?

- A. Renal artery avulsion.
- B. Shattered kidney.
- C. Deep laceration to the collecting system.
- D. Subcapsular haematoma.
- E. Parenchymal contusion.

54. A 54-year-old woman with no history of major illness is incidentally discovered to have a small, solid enhancing lesion on CT at the lower pole of the right kidney. The CT has been performed pre and post intravenous contrast. The lesion measures 9 mm in size. What is the most appropriate management for this lesion?
- Nephron sparing surgery.
 - Percutaneous biopsy.
 - Repeat CT in 3–6 months.
 - Right nephrectomy.
 - Lesion ablation.
55. A 55-year-old female patient presents to your hospital with a history of recurrent UTIs and gross haematuria. Repeated urine cultures are negative, but analysis reveals copious white and red cells in the urine. The patient fails to improve with antibiotics. A CT scan of renal tracts is carried out, which shows an atrophic right kidney containing calcification. There is also an area of increased density on the unenhanced portion of the scan noted in the upper pole of the kidney, with overlying cortical thinning. There are multiple strictures noted in the ureter, with intervening areas of dilatation, giving a corkscrew appearance. There is extensive coarse calcification noted in the wall of the bladder. A CXR is carried out and is normal. Early morning urine collections finally identify mycobacterium tuberculosis in the urine, confirming the suspicion of renal and urinary tract TB. Which of these features is atypical of renal TB?
- High-density material in the calyceal system.
 - Bladder calcification.
 - Renal calcification.
 - Normal CXR.
 - Corkscrew appearance to the ureter.
56. A 26-year-old female patient is referred to the gynaecology team with a history of primary infertility and oligomenorrhoea. On examination she is hirsute and has a body mass index (BMI) of 31. Which of the following MRI findings are most consistent with her diagnosis?
- High T2WI signal C-shaped cystic masses with thin, longitudinally oriented folds along their interior in both adnexae.
 - Multiple small peripheral rounded high T2WI signal areas with hypointense central stroma in both ovaries.
 - Normal ovaries.
 - A small 'banana'-shaped uterus with a single fallopian tube.
 - A junctional zone of 14 mm with multiple hyperintense T2WI foci.

57. A 12-month-old infant with a history of aniridia and nephroblastomatosis undergoes a follow-up CT of abdomen that demonstrates bilateral enlarged kidneys with a thick rind of homogeneous, non-enhancing, hypodense tissue bilaterally. A focal heterogeneous enhancing mass with cystic change is noted on one side. What is the diagnosis?

- Neuroblastoma.
- Wilms tumour.
- Lymphoma.
- Renal cell carcinoma.
- Cystic nephroma.

58. An 18-year-old mountain bike enthusiast is suspected of sustaining a renal injury after attempting a front wheel touch-up manoeuvre. A laceration to the right kidney is noted on CT, which demonstrates contrast enhancement during the pyelographic phase of the examination. What is the significance of this finding?

- Pre-existing angiolipoma.
- Active haemorrhage.
- Devascularization.
- Renal infarction.
- Urine leak.

59. A 45-year-old man has a complex cyst identified in the right kidney on an ultrasound scan performed to assess non-specific epigastric pain. He subsequently has a CT scan of kidneys carried out pre and post administration of intravenous contrast. You classify the complex cyst as IIF (II requiring follow-up) according to the Bosniak classification. Which of the following features is most likely seen at CT imaging?

- Presence of calcification.
- Thickened smooth wall with enhancement.
- Multiple thin non-enhancing septa.
- Hypertenuating cyst <3 cm in size.
- Thickened irregular wall.

60. A 25-year-old male patient presents to A&E with left renal angle pain, radiating to the groin and significant haematuria on dipstick urinalysis. His kidneys, ureters, and bladder (KUB) x-ray is normal. He has a CT KUB, which shows no evidence of a calculus, but a mildly dilated left renal system as far as the mid ureter with peri-ureteric stranding to this point. Given the classical history, the patient undergoes an MR urogram, which shows a filling defect in the mid left ureter and a diagnosis of an obstructing ureteric calculus is made. The patient is observed and this diagnosis is confirmed when the patient passes a calculus the following day. The patient has a relevant past medical history, which led you to suspect a calculus in spite of the CT findings. Which of these clinical histories would lead you to suspect this?

- Recurrent proteus infection.
- HIV-positive patient on antiretroviral therapy.
- Dehydrated patient.
- Familial history of xanthine calculi.
- Gout.

61. A 43-year-old woman with a history of breast carcinoma undergoes a CT of abdomen for abdominal pain and menorrhagia. This reveals an enlarged uterus and she proceeds to MRI. The normal T2WI zonal anatomy of the uterus is preserved. The endometrial stripe is of high T2WI signal and measures 14 mm in diameter, and the myometrium is thickened. Lattice-like enhancement of the high-signal T2WI endometrial area is demonstrated on T1WI post contrast administration. There is no evidence of myometrial invasion. What is the diagnosis most consistent with these findings?

- Intrauterine contraceptive device (IUCD).
- Tamoxifen therapy.
- Lymphoma of the uterus.
- Endometrial stromal sarcoma.
- Pelvic congestion syndrome.

62. A 28-year-old male with a history of von Hippel Lindau disease and a 3-cm renal cell carcinoma undergoes cryo-ablation. Which of the following is suggestive of incomplete treatment/recurrence?

- Hypodense ablation zone larger than the original tumour.
- Lack of enhancement in the ablation zone.
- Ablation zone unchanged in size over time.
- Peripheral ring enhancement.
- Perinephric fat-stranding post procedure.

63. A 22-year-old male front seat passenger is admitted following a RTA. On examination in A&E, blood is noted at the external urethral meatus and there is swelling of the penis. An urethrogram is performed which demonstrates contrast extravasation below the urogenital diaphragm only. What type of urethral injury does this represent?
- Anterior urethral injury.
 - Disruption of the membranous urethra.
 - Bladder neck injury extending into the proximal urethra.
 - Bladder base injury.
 - Penile fracture.
64. A 46-year-old man presents with a 6-week history of painless haematuria. A CT urogram is performed and this demonstrates a 4-cm left renal mass, which is centrally placed involving both cortex and medulla. Which of the following findings will be most helpful when determining if this is a TCC invading the cortex, rather than a renal cell carcinoma invading the collecting system?
- Presence of calcification.
 - Necrosis within the mass.
 - Renal vein invasion.
 - Maintenance of reniform shape.
 - Hypovascularity of lesion to renal parenchyma.
65. A 38-year-old patient is referred for an urgent IVU and ultrasound by their GP, who has picked up mild renal impairment on recent blood tests. The ultrasound shows two normal-sized kidneys with no evidence of cortical loss. The IVU shows a normally enhancing renal outline, but the pelvicalyceal system is abnormal. Some calyces show a non-specific clubbed or blunted appearance. Thin tracks are noted extending from other calyces. In a number of calyces there is a filling defect noted within a rounded, blunted calyx. From these appearances you are able to make a diagnosis. The patient has a classical history for this condition. From the given options, what is the most typical history?
- Recent history of acute hypotension on a background of dehydration.
 - Pyrexia, renal angle pain, and urine culture positive for *E. coli*.
 - Chronic non-steroidal anti-inflammatory drug (NSAID) analgesic overuse.
 - Previously diagnosed reflux nephropathy.
 - History of TCC within bladder.

66. A 37-year-old woman presents with a watery vaginal discharge and attends for an MRI of pelvis. She becomes quite claustrophobic at the end of the scan and you are called to assess her as she has been hyperventilating and the radiographers have become concerned. As you reassure her, you notice some peri-oral pigmentation. The MRI reveals a multicystic lesion (high T1WI and low T2WI signal) in the uterine cervix with a solid (low signal T1WI and T2WI) component in the deep cervical stroma. You note from the picture archiving and communication system (PACS) system that a barium enema previously revealed several colonic polyps. What is the likely cause for the MRI findings?

- A. Malignant melanoma of the cervix.
- B. Carcinoid tumour of the cervix.
- C. Cervical pregnancy.
- D. Minimal deviation adenocarcinoma of the cervix.
- E. Invasive cervical squamous cell carcinoma.

67. A 48-year-old woman presents with shortness of breath and undergoes an HRCT of the chest to assess interstitial changes seen on plain film. She has emigrated from Eastern Europe and knows that she had a gynaecological cancer that was treated there, but is unsure of her treatment. The HRCT reveals unilateral thickened interlobular septa, perilymphatic nodules, and ipsilateral hilar adenopathy. What is the most likely underlying diagnosis?

- A. Cervical carcinoma.
- B. Ovarian epithelial carcinoma.
- C. Endometrial carcinoma.
- D. Leiomyosarcoma of the uterus.
- E. Vaginal carcinoma.

68. A 30-year-old female patient with a history of infertility is referred for an HSG. She has a past history of pelvic inflammatory disease. HSG reveals multiple small outpouchings from the uterine cavity. What is the diagnosis?

- A. Salpingitis isthmica nodosa.
- B. Asherman syndrome.
- C. Adenomyosis.
- D. Endometritis.
- E. Multiple endometrial polyps.

69. A 14-year-old female presents with a history of cyclic pelvic pain. Speculum vaginal examination reveals a bulging vaginal mass. An MRI of the pelvis demonstrates divergent uterine horns with a deep midline fundal cleft, two separate uterine cavities, two separate cervixes, and a unilateral hemivaginal septum causing hematometrorrhocolpos. There is associated renal agenesis on the side of the hemivaginal septum. What is the primary uterine anomaly?
- Uterus didelphys.
 - Uterine bicornuate bicollis.
 - Septate uterus.
 - Arcuate uterus.
 - Imperforate hymen.
70. An 18-year-old male fractures his pelvis following a motorcycle accident. He is suspected of sustaining a bladder injury and undergoes CT cystography. This reveals ill-defined contrast medium within the peri-vesical space with a 'molar-tooth' appearance. What is the significance of this finding?
- Interstitial bladder injury.
 - Intraperitoneal rupture.
 - Extraperitoneal rupture.
 - Combined intra- and extraperitoneal rupture.
 - Bladder contusion.
71. A 54-year-old woman is noted to be hypercalcaemic after complaining of lethargy and abdominal pain. Subsequent biochemical testing reveals an elevated parathyroid hormone. She is referred for scintigraphy with ^{99m}Tc sestamibi. Which of the following radiological findings would suggest a diagnosis of parathyroid adenoma?
- Focus of decreased radionuclide activity within the lower pole of the right lobe of thyroid on initial and delayed images.
 - Focus of decreased radionuclide activity within the lower pole of the right lobe of thyroid on delayed images only.
 - Focus of increased radionuclide activity within the lower pole of the right lobe of thyroid on initial and delayed images.
 - Focus of increased radionuclide activity within the lower pole of the right lobe of thyroid on initial images only.
 - Focus of increased radionuclide activity within the lower pole of the right lobe of thyroid on delayed images only.

72. A 50-year-old man is discovered to have a cystic abnormality at the lower pole of the left kidney during an ultrasound scan performed for right upper quadrant pain. You think this might be a complex cystic lesion and therefore recommend a CT scan of renal tracts. This shows a conglomeration of variable sized cysts at the lower pole of the left kidney, but no capsule or mural irregularities of the cysts. What is the most likely diagnosis?

- A. Localized cystic renal disease.
- B. Multilocular cystic nephroma.
- C. Renal lymphangiomatosis.
- D. Cystic clear cell carcinoma.
- E. Multicystic dysplastic kidney.

73. A 32-year-old patient with a history of renal failure has undergone a renal transplant in your centre. You are carrying out serial ultrasound investigations over the weekend to assess the success of the transplant. The graft was a cadaveric transplant. The initial ultrasound scan showed evidence of perigraft collection, but did show mild renal pelvic dilatation. The pulsatility index (PI) was 2.0 and the resistive index was 0.9. The patient was oliguric. Due to the fears of acute rejection, the patient was commenced on cyclosporine and steroids. The patient, now day 4, is currently anuric and has developed pain over the graft site. You have done an ultrasound. The arterial flow in the kidney has changed. Proximally you notice reversal of diastolic flow evident on spectral waveforms, but in other areas there is no flow evident in the interlobar arteries. Flow is still present in the main renal artery. The RI is now 0.95 and the PI is unchanged. There is still mild renal pelvic dilatation, but you notice a tubular structure of intermediate echogenicity in the renal hilum. There is no evidence of perigraft collection. What do you think the most appropriate next investigative/therapeutic step is?

- A. Continue immunosuppression and further observation, with appropriate fluid administration.
- B. Continue immunosuppression and renal biopsy.
- C. Refer for immediate arterial intervention.
- D. Refer for immediate venous intervention.
- E. Nephrostomy.

74. You are asked to assess a renal transplant kidney in the early post-operative period for any abnormality and to serve as a baseline study. Which of the following findings on colour Doppler ultrasound with regard to the PI, RI and B mode ultrasound imaging, with regard to renal morphology, would be considered within normal limits?

- PI < 1.5, RI < 0.7, loss of cortico-medullary differentiation.
- PI < 1.5, RI < 0.7, prominence of renal pyramids.
- PI < 1.8, RI < 0.7, loss of cortico-medullary differentiation.
- PI < 1.8, RI < 0.7, prominence of renal pyramids.
- PI < 1.5, RI > 0.9, loss of cortico-medullary differentiation.
- PI < 1.5, RI > 0.9, prominence of renal pyramids.
- PI < 1.8, RI > 0.9, loss of cortico-medullary differentiation.
- PI < 1.8, RI > 0.9, loss of cortico-medullary differentiation.
- PI > 1.8, RI > 0.9, prominence of renal pyramids.

75. A 28-year-old para 0 + 0 female patient is referred from the gynaecology team for an MRI of pelvis, after presenting with pain in the RIF. On TVUS they have identified enlargement of the right ovary and have raised the possibility of a mass. On MRI, a 2-cm ovoid lesion is demonstrated within the right ovary. It is of high signal on T1WI and T1WI fat saturation sequences, and low signal on T2WI sequences. There is no evidence of a mural nodule or ascites and the uterus is not enlarged. What is the most likely diagnosis?

- Fibroadenoma.
- Endometriotic cyst.
- Brenner tumour.
- Simple follicular cyst.
- Endometrioid carcinoma.

1.A. Xanthogranulomatous pyelonephritis (XGP).

This is most commonly secondary to proteus infection. XGP is discussed elsewhere in this chapter.

2.D. Adenomyosis.

This appears as focal or diffuse thickening of the junctional zone of 12 mm or greater. Thickening of 8–12 mm is indeterminate, while thickening less than 8 mm usually allows exclusion of the disease. The bright foci on T2WI correspond to islands of ectopic endometrial tissue and cystic dilatation of glands, and have been reported to be present in up to 50% of cases of adenomyosis. Occasionally haemorrhage within these areas of ectopic endometrial tissue can result in areas of high signal within the junctional zone on T1WI.

Pseudotickening of the junctional zone can mimic adenomyosis. It occurs in the menstrual phase (especially the first 2 days) and thus scanning should not be performed at this time. Myometrial contractions can also mimic adenomyosis, but they result in focal, rather than diffuse, thickening of the junctional zone. The contractions are transient and thus will not persist on different sequences. They can therefore be more easily detected with multiphase–multisection imaging, rather than static fast SE. Neither pseudotickening nor myometrial contractions alone would result in high T2WI foci.

The appearances are not consistent with endometrial carcinoma or hyperplasia.

Tamaki K, Togashi K, Ito T, Morisawa N, Fujiwara T, and Koyama T. MR imaging findings of adenomyosis: correlation with histopathologic features and diagnostic pitfalls. *RadioGraphics* 2005; 25: 21–40.

3.B. Transitional cell carcinoma (TCC).

The appearance of ureteral dilatation around and below an intraluminal filling defect is described as the 'goblet' sign. This sign indicates that the filling defect is caused by a chronic process, which allows dilatation of the ureter immediately below to accommodate the lesion. In addition to TCC, this appearance may rarely be seen with metastatic disease or endometriosis.

Chronic analgesic use is a risk factor for TCC.

Pyeloureteritis cystica appears as multiple small filling defects in the renal pelvis and ureter, typically seen in diabetics.

Browne RFJ, Meehan CP, Colville J, Power R, and Torregiani WC. Transitional cell carcinoma of the upper urinary tract: spectrum of imaging findings. *RadioGraphics* 2005; 25: 1609–1627.

4.C. Gynaecomastia.

Most male breast lumps are benign, with breast cancer accounting for <1% of all breast lesions. Gynaecomastia is the most common benign condition of the male breast. The radiological description is in keeping with early nodular gynaecomastia. Lipomas are encapsulated fatty masses on mammography, which are mildly hyperechoic on ultrasound. Approximately 85% of

male breast cancer is invasive ductal carcinoma. This is typically retroareolar and hyperdense on mammography with irregular margins. Secondary features such as nipple retraction and skin thickening are usually present. Ultrasound will show a non-parallel, hypoechoic mass. Posterior acoustic features and internal blood flow are not useful for distinguishing benign versus malignant lesions. Lymphoma will exhibit multiple hyperdense lymph nodes on mammography. Dermatofibrosarcoma is hyperechoic on ultrasound.

Chen L, Chandra PK, Larsen LH, Barton P, Rohitopakarm M, Zhu EQ et al. Imaging characteristics of malignant lesions of the male breast. *Radiographics* 2006; 26: 993–1006.

5.C. Fibrothecoma of the ovary.

Ovarian fibroma is the most common sex-cord stromal neoplasm and is almost always benign. Occasionally there will be histologic features of both fibroma and thecoma, giving rise to the term 'fibrothecoma'. These are typically solid lesions on ultrasound and have marked acoustic shadowing in 18–52% of cases. This shadowing is not secondary to calcification, but is related to marked attenuation of sound by the dense hypoechoic mass itself. This can be a useful sign for identifying fibrothecoma on ultrasound.

Classification of ovarian neoplasms is based on histologic features and typically includes

the general categories of epithelial, germ cell, sex cord-stromal, and metastatic neoplasms. Cystadenomas/denocarcinomas belong to the epithelial group of malignancies and make up over 90% of primary ovarian malignancies.

Sertoli–Leydig cell tumours, granulosa cell tumours, and fibrothecomas belong to the sex cord-stromal group of neoplasms. Sertoli–Leydig cell tumours may be subtle on ultrasound, as many are small and solid. They can secrete androgens and cause virilization. Granulosa cell tumours often have a sponge-like consistency and may produce oestrogen and cause endometrial disease. Dysgerminomas and embryonal cell carcinomas are very rare germ cell neoplasms. The

most common germ cell neoplasm is of course a mature cystic teratoma (dermoid cyst). A hyperechoic area (not usually as intensely echogenic as calcification) with acoustic shadowing is highly predictive of this lesion. Hyperechoic lines and dots, sometimes known as the dermoid mesh, are also highly predictive of a mature teratoma. Less common associated signs include fluid–fluid level and floating globules. Calcification can be seen, but is not specific to dermoids, as other ovarian neoplasms can calcify.

Brown DL, Dudak KM, and Laine FC. Adnexal masses: US characterisation and reporting. *Radiology* 2010; 254: 342–354.

6.C. Grade 3.

Whilst most commonly associated with congenital reflux in children, acquired reflux is also seen, most commonly due to bladder outlet obstruction or recurrent cystitis. Grade 1 reflux demonstrates reflux into the ureter; grade 2 has reflux into the pelvicalyceal system; grade 3 as described, and grade 4 is as grade 3 but with increased pelvoureteric dilatation and calyceal blunting, and with persisting papillary impressions. Grade 5 demonstrates a markedly dilated pelvis and tortuous ureter with obliteration of the fornical angles and papillary impressions. Dahner W. *Radiology Review Manual*, 5th edn, Lippincott Williams & Wilkins, 2007, p. 983.

7.C. recommend a repeat trans-abdominal ultrasound in 6 weeks' time.

At ultrasound, a functional ovarian cyst is typically anechoic with a thin, smooth wall and posterior acoustic enhancement. Regardless of size, these cysts are unlikely to be malignant. A unilocular cyst greater than 3 cm in a premenopausal or greater than 5 cm in a postmenopausal female patient should be rescanned in approximately 6 weeks (which will usually be at a different stage of the menstrual cycle in the case of premenopausal patients). Premenopausally this is

the case, even if there are some internal echoes (but not other findings raising the possibility of malignancy), as these quite often represent haemorrhage within a cyst. In the premenopausal patient, the follow-up scan is to ensure there is reduction in size or resolution of what is usually benign. Sonographic findings which increase the likelihood of malignancy include wall thickening, then, in the absence of other sinister findings or history, it can be assumed that the cysts are benign. Sonographic findings within solid elements, abnormal blood flow, and findings of metastatic disease. If a cyst displays any of the latter features or increases in size on interval scanning, then options A, B, and D may be valid steps in management.

Ally J, Hoey E, Wolstenhulme S, and Weston M. *Practical Ultrasound: An Illustrated Guide*, Royal Society of Medicine Press Ltd, 2006, p. 200.

Levine D. Gynaecologic ultrasound. *Clinical Radiology* 1998; 53: 1-9.

8. B. Renal imaging.

Mullerian duct anomalies are associated with renal tract anomalies in up to 30% of cases due to the close embryologic relationship between the Mullerian and mesonephric ducts. The most common renal tract abnormality is renal agenesis. Other associated anomalies include duplicated collecting system, renal duplication, horseshoe kidney, crossed renal ectopy, and cystic renal dysplasia. Renal imaging is therefore essential in all patients with Mullerian duct anomalies. Surgical intervention is not required in patients with a unicornuate uterus and a non-functioning rudimentary horn.

Junqueira BLP, Allen LM, Spitzer RF, Lucio KL, Babyn PS, and Doria AS. Mullerian duct anomalies and mimics in children and adolescents: correlative intraoperative assessment with clinical imaging. *Radiographics* 2009; 29: 1085-1103.

9. D. Dot-dash.

Malignant calcifications vary in shape and size. Pleomorphic calcifications that are more linear or dot-dash in appearance are associated with intraductal carcinoma. DCIS is often detected as a result of such calcifications. Egg-shell calcification is seen in the walls of an oil cyst. Sedimented calcium appears as curvilinear on the lateral projection and as smudged on the cranio-caudal view. This is a feature of benign cysts. Arterial calcification presents as tubular, parallel calcification. Fibroadenomas typically exhibit large, coarse, and irregular calcification.

Brant WE and Helms CA. *Fundamentals of Diagnostic Radiology*, 3rd edn, Lippincott Williams & Wilkins, 2007, pp. 580-582.

10. B. The presence of aneurysmal blood vessels within the lesion.

Both well-differentiated retroperitoneal liposarcomas and exophytic renal angiolipomas can be very large in size and thus size is not a discriminating factor. Both contain large amounts of mature lipid, thus significant portions of the lesion will have negative Hounsfield attenuation values on CT imaging.

Aneurysmal blood vessels are commonly seen in large angiolipomas, whereas well-differentiated liposarcomas are generally rather hypovascular lesions. Both angiolipomas and retroperitoneal liposarcomas may contain areas of soft tissue density. Liposarcoma is probably more likely to have an irregular margin and may contain areas of fluid density.

Israel GM and Bosniak MA. Pitfalls in renal mass evaluation and how to avoid them. *Radiographics* 2008; 28: 1325-1338.

11.D. XGP

Whilst the patient presents with the classical renal cell carcinoma (RCC) triad of loin pain, haematuria, and a mass, this triad is actually only present in 30% of patients with RCC. These features are also typically found in XGP. The key finding in this case is of areas of fatty attenuation within the mass, in association with a staghorn calculus. Calculi are found in 80–90% of cases of XGP. The long history of symptoms is also typical of XGP, which can be present for up to 6 months prior to diagnosis. Lymphoma, RCC, and renal oncocytoma would not typically have areas of fatty tissue within them. Angiomyolipomas, in the absence of tuberculous sclerosis, are typically solitary. They are usually well defined, unlike in this case, and would rarely reach this size without having previously caused symptoms. XGP is typically found in diabetic patients and is due to proteus infection. Treatment is with nephrectomy.

Dahner W. *Radiology Review Manual*, 5th edn, Lippincott Williams & Wilkins, 2007, p. 944.

12.D. Eagle Barrett syndrome.

Eagle Barrett syndrome or prune belly syndrome is classically defined as a triad of partial or complete absence of abdominal musculature (resulting in bulging flanks), cryptorchidism, and urinary abnormalities as described above. In addition a number of respiratory, GI, musculoskeletal, and cardiovascular anomalies are associated with this syndrome.

It occurs almost exclusively in males. The cause and embryogenesis remain controversial. Bladder outlet obstruction, mesodermal arrest, and dysgenesis of the yolk sac have been proposed as possible causes.

Bercoff T, Lopez-Pereira P, Arjonilla A, and Gutierrez J. Anomalies of the distal ureter, bladder, and urethra in children: embryologic, radiologic and pathologic features. *Radiographics* 2002; 22: 1139–1164.

13.B. Spiculated margin.

A recent study examining incidental breast lesions detected by CT found that spiculated breast lesions and axillary lymphadenopathy should raise concern for malignancy and be referred to the breast clinic. These features were significantly more likely to be present in malignant breast lesions. Genuine mass lesions and spiculation are more easily appreciated in non-dense breasts. The mammographic features of ill-definition and calcification do not appear to be suggestive of malignancy on CT, probably due to poorer resolution, as normal breast glandular tissue appears ill-defined on CT and malignant microcalcification is poorly demonstrated. Lesion size and location also do not differentiate between benign and malignant disease.

Porter G, Steel J, Paisley K, Watkins R, and Holgate C. Incidental breast masses detected by computed tomography: are any imaging features predictive of malignancy? *Clinical Radiology* 2009; 64: 529–533.

14.B. Renal oncocytoma.

This is a benign renal cell neoplasm responsible for about 5% of all adult primary renal epithelial neoplasms. It typically occurs in elderly men. They usually appear as solitary, well-demarcated, unencapsulated, fairly homogeneous renal cortical tumours. Bilateral, multicentric oncocytomas are seen in hereditary syndromes of renal oncocytosis and Birt-Hogg-Dubé syndrome. A central stellate scar is seen in approximately one-third. However, distinguishing them from RCC on imaging is not reliable. Leiomyoma of the kidney is a benign smooth muscle neoplasm. It appears as a well-circumscribed, homogeneous, exophytic solid mass that shows uniform enhancement on contrast-enhanced CT. It may occasionally be cystic.

Metanephric adenoma is a benign renal neoplasm that is more common in middle-aged to elderly females. It is associated with polycythaemia in 10%. It typically appears as a well-defined,

unencapsulated, solitary mass that may be hyperattenuating on unenhanced CT. Calcification can be seen in up to 20%.

Hemangioma of the kidney occurs as an unencapsulated, solitary lesion that frequently arises from the renal pyramids or the pelvis. Contrast-enhanced CT or MRI may show early intense enhancement, with persistent enhancement on delayed images.

Juxtaglomerular cell (JGC) neoplasm or reninoma is an extremely rare, benign renal neoplasm of myoendocrine cell origin, which is associated with a clinical triad of hypertension, hypokalaemia, and high plasma renin activity. It typically appears as a unilateral, well-circumscribed, cortical tumour and often measures less than 3 cm, but otherwise is indistinguishable from other cortical neoplasms.

Prasad SR, Swabhi VR, Menias CO, Raut AA, and Chintapalli KN. Benign renal neoplasms: cross-sectional imaging findings. *American Journal of Roentgenology* 2008; 190: 158–164.

15. B. Empysematous pyelitis.

The combination of these radiological findings in a septic diabetic patient indicates an infection with a gas-forming organism, usually *E. coli*. The gas is located entirely within the pelviccalyceal system, as opposed to the renal parenchyma, which would indicate a diagnosis of emphysematous pyelonephritis. The importance is in the urgency of treatment and prognosis. Empysematous pyelonephritis carries a grave prognosis and often requires nephrectomy for life-saving treatment, whereas the prognosis with emphysematous pyelitis is not as grave and it often responds to antibiotics with possible urinary drainage procedures if necessary.

Dahner W. *Radiology Review Manual*, 5th edn, Lippincott Williams & Wilkins, 2007, p. 944.

Narlawar R, Raut A, Nagar A, Hira P, Hanchate V, and Asrani A. Imaging features and guided drainage in emphysematous pyelonephritis: a study of 11 cases. *Clinical Radiology* 2004; 59: 192–197.

16. D. Referral for surgery.

The findings are consistent with a mature cystic teratoma or dermoid cyst. They are derived from all three germ cell layers and thus contain fat and may contain desquamated epithelium, skin, hair, and teeth. The classical finding is of high T1WI signal, which suppresses on fat saturation imaging. They can often have a fat-fluid level. The low signal on T2WI may represent tooth or calcification. Soft-tissue protruberances represent Rokitansky nodules or 'dermoid plugs' of sebaceous material.

It is the most common ovarian tumour, accounting for 20% of all ovarian neoplasms. Dermoids can be bilateral in 8–25% of cases. The chance of malignant transformation is low but surgical resection is indicated, not just for relief of symptoms, but because of the risk of torsion (in 4–16% of cases) or rupture (the latter is rare but can lead to chemical peritonitis). Adjuvant treatment need not be considered unless the case is complicated by malignant transformation.

Izumi I, Wada A, Kajiy T, Hayashi T, Hayashi M, and Matsuo M. Developing an MR imaging strategy for diagnosis of ovarian masses. *Radiographics* 2006; 26: 1431–1448.

Dahner W. *Radiology Review Manual*, 5th edn, Lippincott Williams & Wilkins, 2003, pp. 1028–1029.

17. D. Utero-ovarian anastomosis is identified in less than 5% of cases.

Uterine arteries are the predominant source of blood supply to the fibroids in most cases. There is considerable variation in the pelvic arterial anatomy, a thorough knowledge of which is essential to carry out uterine artery embolization safely and effectively.

The internal iliac artery bifurcates into anterior and posterior divisions in 57–77% of the general population. The uterine artery arises as the first or second branch of the anterior division of

internal iliac artery in 51% of cases. The internal iliac artery trifurcates into uterine artery, the anterior, and the posterior divisions in 15–40% of the general population. The uterine artery arises as the first branch of the internal iliac artery in 6% of cases.

The uterine artery may be replaced by small branches or may be absent. The ipsilateral ovarian artery often replaces an absent uterine artery. Ovarian arterial supply to fibroids is more common in those with previous history of pelvic surgery or tubo-ovarian disease and/or large fundal fibroids. The extent of ovarian supply should be assessed with flush pelvic aortography, preferably after uterine artery embolization.

The ovarian artery arises from the aorta just below the renal arteries in 80–90% of cases and has a characteristic corkscrew appearance. Normal ovarian arteries are not usually identified on angiography because of their small calibre.

Utero-ovarian anastomosis is seen in 10–30% of cases and left-to-right uterine anastomosis in 10% of cases.

Pelage J-P, Cazejust J, Plout E, le Dref O, Laurent A, Spies JB et al. Uterine fibroid vascularization and clinical relevance to uterine fibroid embolisation. *Radiographics* 2005; 25: S99–S117.

18. C. Multiple curvilinear lines of low T2WI signal within the implant.

Silicone gel implants are high signal on T2WI. Capsular contracture is caused by constriction of the fibrous capsule that invariably forms to some degree around the implant as a reaction to the foreign object. This is seen on MRI as increased thickening of the T2WI hypointense margin surrounding the implant. Rupture of the prosthesis is the most common complication with breast implants, occurring in up to 10–20%, although many are not noticed clinically. With intracapsular ruptures, the silicone gel is contained by the capsule. Curvilinear strands of low T2 signal within the capsule may be seen, representing the collapsed implant shell. This finding is known as the 'linguine' sign. T2WI hypointense globules surrounding the implant are indicative of an extracapsular rupture. Inferior extension beyond the inframammary fold implies migration, which is a relatively uncommon occurrence. Marginal T2WI hypointense radial folds within the implant are a normal finding.

DeAngelis GA, de Lange EE, Miller LR, and Morgan RF. MR imaging of breast implants. *Radiographics* 1994; 14: 783–794.

19. A. Lymphoma.

Clinically testicular lymphoma is distinct from other testicular neoplasms in that it occurs in a much older age group. It is the most common testicular neoplasm over the age of 60 years. It is also the most common bilateral testicular neoplasm (up to 38% of cases). The epididymis and spermatic cord are commonly involved. The sonographic appearance is variable and indistinguishable from germ cell tumours. Typically they are discrete hypoechoic lesions that may completely infiltrate the testicle.

Primary leukaemia of the testis is rare, although it is a common site of leukaemia recurrence in children. The sonographic appearances are very variable, as the tumour may be unilateral or bilateral, focal or diffuse, hypoechoic or hyperechoic.

Testicular metastases, other than those from lymphoma or leukaemia, are very rare. Primary sites reported include prostate and lung. They are generally seen in the setting of widespread disease and are rarely the presenting complaint.

Seminoma is the most common germ cell tumour. The average age of presentation is approximately 40 years. It is typically uniformly hypoechoic on ultrasound and they are only rarely bilateral (2%).

Granulomatous orchitis may manifest as a testicular mass, but this would be very unusual. Typically this process tends to involve the epididymis first and to a much greater degree than the testis. Pathogens include TB, syphilis, fungi, and parasites.

Woodward PJ, Sohaey R, O'Donoghue MJ, and Green DE. From the archive of the AFIP – tumor and tumorlike conditions of the testis: radiologic-pathologic correlation. *Radiographics* 2002; 22: 189–216.

20.A. Malakoplakia.

This is an inflammatory response to chronic *E. coli* infection. It is more common in females and in diabetic/immunocompromised patients. It most commonly occurs in the bladder and distal ureter and is multifocal in 75% of cases.

Dahner W. *Radiology Review Manual*, 5th edn, Lippincott Williams & Wilkins, 2007, p. 924.

Wasserman N. Inflammatory diseases of the ureter. *Radiological Clinics of North America* 1996; 34: 1131–1156.

21.A. Serum parathyroid hormone assay and ^{99m}Tc sestamibi scan.

Clinical findings, blood tests, and CT of the abdomen are diagnostic of parathyroiditis. The most common causes for parathyroiditis are alcohol and cholelithiasis. Rarely, it may be caused by hyperparathyroidism. The associated findings on CT are suggestive of hyperparathyroidism, therefore further assessment with serum parathyroid hormone assay and ^{99m}Tc sestamibi scintigraphy is indicated. ^{99m}Tc sestamibi washes out more rapidly from the thyroid gland than from hyperfunctioning parathyroid glands and therefore it can be used on its own.

MIBG, a noradrenaline analogue, is used in the evaluation of neuroblastomas and paragangliomas. ^{99m}Tc pertechnetate is taken up by the thyroid gland only and is therefore not useful on its own in parathyroid imaging. However, it can be used in combination with ²⁰¹Tl, which is taken up by both thyroid and parathyroid. Subtracting the two scintigrams allows parathyroid localization.

Estamly HK and Zeissman HA. Parathyroid scintigraphy in patients with primary hyperparathyroidism. *^{99m}Tc sestamibi SPECT and SPECT/CT*. *Radiographics* 2008; 28: 1461–1476.

22.A. Irregular margin.

A woman over the age of 30 years who is a BRCA1 or BRCA2 carrier should be offered MRI annually for breast cancer surveillance. The description of the margin of the mass is the most predictive feature of the breast MR image interpretation. Irregular or spiculated margins have a positive predictive value of 84–91%. T2W signal hyperintensity is suggestive of benign pathology, but not in the setting of an irregular or spiculated mass. There is overlap in enhancement kinetics between benign and malignant disease, and thus reliance on kinetic assessment alone is not recommended. Progressive enhancement (type I) is associated with benign pathology, whereas plateau (type II) and washout (type III) curves are suggestive of malignant disease. Due to the importance of lesion morphology, the MRI technique should focus on optimizing high spatial and temporal resolution.

Macura KJ, Ouwertker R, Jacobs MA, and Bluemke DA. Patterns of enhancement on breast MR images: interpretation and imaging pitfalls. *Radiographics* 2006; 26: 1719–1734.

23.D. Tubular ectasia of the rete testis.

This is also known as cystic transformation of the rete testis and results from partial or complete obliteration of the efferent tubules, which causes ectasia and eventually cystic transformation. It is frequently bilateral, but may be asymmetric. The site is in or adjacent to the mediastinum testis and there are often associated epididymal cysts or spermatoceles. The key to the correct identification of this abnormality is the elongated shape that replaces the mediastinum.

Intratesticular varicoceles can occur, but they are very rare. It would be even rarer for it to be thrombosed.

Testicular abscess would not usually be multicystic, but would be more rounded with an irregular wall and low-level internal echoes.

Testicular infarction usually manifests as a hypoechoic mass that is largely avascular; it is not usually cystic.

Epidermoid cyst is a rare benign tumour of germ cell origin. It is usually rounded or oval in shape and classically has a 'target' or 'onion skin' appearance of alternating layers of hyper- and hypo-echogenicity. The outer wall is typically hyperechoic and sometimes calcified.

Dogra VS, Gottlieb RH, Rubens DJ, and Liao L. Benign intratesticular cystic lesions: US features. *Radiographics* 2001; 21: S273-S281.

24. E. No intervention.

The factors described are all indicators of poor outcome following renal artery intervention. Reduced renal size bilaterally indicates advanced bilateral renal disease, unlikely to respond to intervention. The renal ultrasound Doppler patterns are also not suggestive of renal artery stenosis, which is indicated by a peak systolic velocity of greater than 180 cm/s. Resistive indices of greater than 0.7 indicate a likelihood of improvement after intervention.

Morgan R and Walitzer E. *Handbook of Angioplasty and Stenting Procedures*. Springer, 2010, p. 152.

25. D. Bartholin's gland cyst.

Bartholin's glands are located behind the labia minora and their ducts open onto the posterolateral vestibules on each side. The cysts are due to blockage of the ducts and retention of secretions. They are common in reproductive age and are usually cystic in appearance (high T2WI signal). Their T1WI signal is variable and can be high due to mucoid content. They are usually discovered as incidental findings on imaging for another cause, although they may be palpable or clinically visible. The radiologist should recognize them as a benign pathology.

Primary carcinoma of the vagina is rare, as 80–90% of tumours affecting the vagina are due to extension of primary bladder, cervical, vulval, or rectal tumours. Ninety per cent of primary carcinomas are squamous cell carcinoma. The majority occur in elderly women and the two most common presenting complaints are vaginal discharge and bleeding. Squamous cell carcinomas of the vagina are usually of low T1WI and intermediate T2WI signal. As for vulval and cervical squamous cell carcinoma, human papilloma virus (HPV) infection is a risk factor.

Urethral diverticula are best seen on T2WI sequences as hyperintense lesions adjacent to or surrounding the urethra: a connection to the urethra is not always seen. They are usually of low signal on T1WI sequences. They predispose to stones (low signal on T2WI sequences) and carcinoma (enhancing on T1W fat saturation post gadolinium).

Nabothian cysts are found at the external os of the cervix. They are benign retention cysts that develop secondary to obstruction of endocervical glands. They have high T2WI signal and may have high T1WI signal due to mucinous content. They are usually multiple and measure less than 2 cm. They become clinically relevant when they are mistakenly diagnosed as adenoma malignum, a subtype of mucinous adenocarcinoma of the cervix.

A vaginal septum is a low-signal T2WI band. If transverse, it may present in adolescence with primary amenorrhoea and abdominal pain, and an abdominal mass if complete. A longitudinal septum is usually asymptomatic and is associated with duplication of the uterus, cervix, or vagina.

Lopez C, Balogun M, Ganesan R, and Olliff JF. MRI of vaginal conditions. *Clinical Radiology* 2005; 60: 648–662.

Siegelman E. *Body MRI*. Elsevier Saunders, 2004, p. 291.

26.A. Repeat fine needle aspiration.

The features suspicious for malignancy on ultrasound are calcification, irregularity, solid lesion, and irregular halo- and hypervascularity. A repeat biopsy should be considered if there is discordance between imaging findings and cytology.

Iyer NG and Shaha AR. Management of thyroid nodules and surgery for differentiated thyroid cancer. *Clinical Oncology* 2010; 22: 405–412.

27.E. Two lives are saved for every over-diagnosed case.

Over-diagnosis is defined as the diagnosis of cancer as a result of screening that would not have been diagnosed in the woman's lifetime had screening not taken place. Approximately 5.7–8.8 breast cancer deaths are prevented per 1000 women screened for 20 years starting at age 50 compared with 2.3–4.3 over-diagnosed cases per 1000 women screened for 20 years. The WHO International Agency for Research on Cancer determined that there is a 35% reduction in mortality from breast cancer among screened women aged 50–69.

The NHS Breast Screening Programme provides screening every 3 years for women between the ages of 50 and 70. After the age of 70, women are still screened, although they are not automatically called for. Expansion is planned to cover women from 47 to 73. A two-view (cranio-caudal and mediolateral oblique) mammogram is taken, performed with breast compression, which can be uncomfortable for the patient.

www.cancerscreening.nhs.uk/breastscreen

Duffy SW, Tabar L, Olsen AH, Vitak B, Allgood PC, Chen THH et al. Absolute numbers of lives saved and overdiagnosis in breast cancer screening, from a randomized trial and from the breast screening programme in England. *Journal of Medical Screening* 2010; 17: 25–30.

28.D. Succenturiate placenta.

This is an additional lobe separate from the main bulk of the placenta. The significance of this variant is the rupture of vessels connecting the two components or retention of the accessory lobe with resultant post-partum haemorrhage.

Circumvallate placenta has a chorionic plate smaller than the basal plate, with associated rolled placental edges. There is known to be an increased risk of placental abruption and haemorrhage with this type of placenta.

A bilobed placenta is a placenta with two evenly sized lobes connected by a thin bridge of placental tissue. This has no known increased risk of morbidity.

Placenta membranacea is a thin membranous structure circumferentially occupying the entire periphery of the chorion. There is an increased risk of placenta praevia, as a portion of the placenta completely covers the internal os.

Placenta accreta is not a variant of placental morphology. It occurs when there is superficial invasion of the chorionic villi of the placenta into the basal layer of the uterine wall. Deeper invasion of the myometrium is termed 'placenta increta'. Even deeper invasion involving the serosa or adjacent pelvic organs is termed 'placenta percreta'. The risk of this is catastrophic intrapartum haemorrhage at the time of placental delivery.

Elsayes KM, Trout AT, Friedkin AM, Liu PS, Bude RO, Platt JF, and Menias CO. Imaging of the placenta: a multimodality pictorial review. *Radiographics* 2009; 29: 1371–1391.

29.B. Patients C and D.

A 70% stenosis is taken as the cut-off for significant stenosis. Patient B is atypical in their age. They also have imaging characteristics typical of fibromuscular dysplasia. Patients C and D have classical imaging features of renal artery stenosis (RAS). With regard to ultrasound diagnosis

using Doppler, this is made by either showing flow acceleration immediately distal to the site of stenosis or showing damped flow in the segmental arteries. In the renal artery, a peak systolic velocity of over 180 cm/s combined with a renal/aortic velocity ratio of over 3 is reported as being the most sensitive method of detecting RAS.

House M, Dowling R, King P, and Gibson R. Using Doppler sonography to reveal renal artery stenosis: an evaluation of optimal imaging parameters. *American Journal of Roentgenology* 1999; 173: 761–765.

Morgan R and Walzter E. *Handbook of Angioplasty and Stenting Procedures*. Springer, 2010, pp. 151–156.

30. B. Adrenal cortical carcinoma.

The clinical picture is one of undiagnosed Cushing's syndrome with obesity and hypertension. In this case it is adrenocorticotrophic hormone (ACTH) independent Cushing's, as the negative feedback from the cortisol producing adrenal carcinoma causes reduction in ACTH levels and atrophy of the contra-lateral, normal adrenal gland.

Adrenal adenoma can cause Cushing's syndrome, but the features described point to adrenal carcinoma. They have a bimodal distribution (first and fourth decades). On average 55% are functional, manifesting with Cushing's syndrome, feminization, virilisation, or a mixture of these. Hypertension is common in all syndrome types. The majority of masses measure more than 6 cm. They are inhomogeneous on unenhanced CT, owing to necrosis. They enhance heterogeneously, often peripherally, with a thin rim of enhancing capsule in some cases. In 19–33% of cases calcification or microcalcifications have been identified. The liver is the most common metastatic site, followed by the lung and lymph nodes. Direct extension and tumour thrombus can also occur. Compression of the IVC can lead to presentation with abdominal pain, lower extremity oedema or pulmonary embolism.

Neuroblastoma is a disease of childhood. Myelolipoma is a relatively uncommon benign adrenal mass containing fat and haemopoietic tissue.

Phaeochromocytoma is classically brightly enhancing, but can have a variety of CT appearances. It would explain hypertension, but not atrophy of the contra-lateral adrenal gland. Phaeochromocytoma rarely invades the IVC.

Johnson PT, Horton KM, and Fishman EK. Adrenal mass imaging with multidetector CT: pathologic conditions, pearls, and pitfalls. *Radiographics* 2009; 29: 1333–1351.

Rockall AG, Babar SA, Sohal SA, Isidor AM, Diaz-Cano S, Monson JP et al. CT and MR imaging of the adrenal glands in ACTH-independent Cushing syndrome. *Radiographics* 2004; 24: 435–452.

31. B. Calcitonin.

Medullary thyroid carcinoma arises from the parafollicular C cells of the thyroid that secrete calcitonin, therefore calcitonin is a useful tumour marker for medullary thyroid carcinoma. CEA is another tumour marker produced by neoplastic C cells.

Thyroglobulin is produced by follicular cells and is therefore not useful in medullary carcinomas. Pacini F, Castagna MG, Cipri C, and Schlumberger M. Medullary thyroid carcinoma. *Clinical Oncology* 2010; 22: 475–485.

32. A. Reassurance and discharge with advice.

The clinical and radiological findings in this case are typical for fibroadenoma. Standard practice for investigating breast lumps involves triple assessment with clinical examination, imaging with ultrasound, and tissue diagnosis (with either cytology or histology). However, in women under the age of 25 who present with a clinically and radiologically benign lump, biopsy is not needed unless there is overriding clinical concern. To be assessed as definitely benign on ultrasound, there

should be no malignant features (spiculation, angular margins, acoustic shadowing, calcification, and marked hypoechogenicity) and the lesion should follow tissue planes (wider than it is tall). The ultrasound should also be performed by an experienced operator. The patient should be advised to seek further assessment if there is any increase in size or change to the mass.

Smith GEC and Burrows P. Ultrasound diagnosis of fibroadenoma – is biopsy always necessary? *Clinical Radiology* 2008; 63: 511–515 (commentary by Dall BJG, *Clinical Radiology*, 2008; 63: 516–517).

33. B. Cortico-medullary phase.

Imaging in the cortico-medullary phase is helpful for showing the normal cortico-medullary pattern in pseudotumours such as prominent columns of Bertin or focal renal hypertrophy. It is also useful for suspected abnormalities such as vascular malformations and pseudodaneurysms of the kidney. The nephrographic phase is best to characterize renal masses. Small parenchymal renal lesions may be hidden in the renal medulla on the cortico-medullary phase and excretory phases. Excretory phases are best to assess for collecting system lesions and the unenhanced scan is best for detection of renal calculi and for using as a baseline in assessing the enhancement characteristics of parenchymal renal lesions.

Israel GM and Bosniak MA. Pitfalls in renal mass evaluation and how to avoid them. *Radiographics* 2008; 28: 1325–1338.

34. D. Arterial phase CT abdomen.

The IVU has surprisingly been helpful in showing a delayed increasing nephrogram, a classical, although uncommon, appearance of renal vein thrombosis. This is also indicated by the history of glomerulonephritis, which can manifest as nephrotic syndrome, the most common cause for renal vein thrombosis. Ultrasound is often successful at identifying a thrombosed right renal vein, but is not useful in assessing the longer left renal vein. Gradient and SE sequences are both helpful in assessing the renal venous system, with GE giving low-signal thrombus and SE giving high-signal thrombus. Arterial phase CT would be too early to show a venous filling defect and thus may not contribute, although it may show a rim nephrogram. Portal venous phase CT is reasonably sensitive at detecting the lack of enhancement within the renal vein and abnormal enhancement pattern within the affected kidney.

Adam A and Dixon A. *Granger and Allison's Diagnostic Radiology. A textbook of medical imaging*. Vol 1, 5th edn, Churchill Livingstone, 2008, Ch 39.

35. D. In- and out-of-phase T1WI.

This is a T1WI technique and will reveal the presence of intracellular lipid via a dropout of signal on the out-of-phase imaging when compared to the in-phase imaging. Thus a benign adrenal adenoma will show such signal dropout (20% or greater in quantity is diagnostic; 10–20% is highly suggestive), whilst adrenal metastases will not. However, approximately 15% of benign adenomas do not accumulate intracellular lipid and may retain signal on the out-of-phase imaging: in such cases, dynamic gadolinium-enhanced images can increase specificity to over 90–95% (by showing washout characteristics as seen on CT). If there is still doubt, PET-CT is useful. Adrenal hyperplasia may also show loss of signal on the out-of-phase imaging. Of note an adrenal cortical carcinoma can show dropout of signal in portions on the out-of-phase sequence, but there is not the uniform loss of signal as seen with adenomas.

The T1WI with fat saturation will show signal dropout in areas of extracellular lipid, e.g. macroscopic fat in lipomas, dermoid cysts, or the subcutaneous tissues. T2WI is not of much benefit in distinguishing benign from malignant adrenal masses unless the tumour is a pheochromocytoma, which can show very high T2WI signal.

Martin D, Brown M, and Semelka, R. *Primer on MR Imaging of the Abdomen and Pelvis*, Wiley, 2005, 223–256.

36. C. Medullary sponge kidney.

Hyperparathyroidism, renal tubular acidosis, and medullary sponge kidney are the three most common causes of medullary nephrocalcinosis. The former two conditions are associated with hypercalcaemia that results in uniform medullary nephrocalcinosis. Sarcoidosis and multiple myeloma are associated with hypercalcaemia resulting in bilateral nephrocalcinosis. Medullary sponge kidney can affect the kidney segmentally, unilaterally, or bilaterally, therefore unilateral nephrocalcinosis is suggestive of medullary sponge kidney.

Medullary sponge kidney is characterized by cystic dilatation of collecting tubules. Urine stasis within the dilated tubules predisposes to infection and calculus formation within the dilated tubules or urinary tracts. On excretory urogram, contrast within the dilated tubules produces a striated 'paintedbrush' appearance of the renal pyramids.

Joffe SA, Servaes S, Okon S, and Horowitz M. Multi-detector row CT urography in the evaluation of hematuria. *Radiographics* 2003; 23: 1441-1455.

Dyer RB, Chen MY, and Zagoria RJ. Abnormal calcifications in the urinary tract. *Radiographics* 1998; 18: 1405-1424.

37. D. Phyllodes tumour.

This most commonly manifests as a rapidly growing mass, which is lobulated on mammography. Calcifications are rarely seen. A solid mass containing cystic spaces on ultrasound and demonstrating posterior acoustic enhancement is strongly suggestive of phyllodes tumour.

Phyllodes tumour can be benign or malignant, but both have a tendency to recur if not widely excised. Adenoid cystic carcinoma is a slow-growing mass that is well defined on mammography. Fibromatosis presents as an indistinct mass on mammography, which is hypoechoic with posterior acoustic shadowing on ultrasound, simulating malignancy. Granular cell tumours are thought to arise from Schwann cells and have a very variable appearance. Metastatic disease to the breast is much more likely to be multiple or bilateral. Diffuse skin thickening is also a feature.

Feder JM, Shaw de Paredes E, Hogg JE, and Wilken JJ. Unusual breast lesions: radiologic-pathologic correlation. *Radiographics* 1999; 19: 511-526.

38. D. Close application of the soft tissue to the adjacent vertebrae.

Unfortunately attempts to consistently distinguish benign retroperitoneal fibrosis (RPF) from malignancy are fraught with danger, but there are certain CT findings which are more commonly seen in one or other of these conditions.

Malignancy tends to be larger and bulkier, displaying mass effect and displacing the aorta and IVC anteriorly from the spine and the ureters laterally. The purely fibrotic process of benign RPF tends to tether these structures to the adjacent vertebrae.

Malignancy is more likely to extend cephalad to the renal hila, with benign RPF remaining caudal to the hila. Neoplasia also more typically has a nodular outline, whereas benign RPF usually manifests as a plaque-like density. There are, of course, exceptions to both these features.

Contrast enhancement is not a reliable feature for distinguishing benign RPF from malignancy, as both malignancy and active RPF can enhance with contrast. Similarly, the degree of

hydronephrosis caused is not a good distinguishing feature.

Cronin CG, Blake MA, Roche C, McCarthy P, and Murphy JM. Retroperitoneal fibrosis: a review of clinical features and imaging findings. *American Journal of Roentgenology* 2008; 191: 423-431.

39.A. Repeat scan in 4 weeks.

There are a number of important points in this question. Firstly, the date from biopsy must be known to avoid misinterpreting haemorrhage as disease on MRI. Fortunately the urologists have provided you with the salient information necessary to estimate disease stage from the Partin's tables. Whilst these are clinical features, they are essential to know when interpreting MRI. The features described indicate a <1% risk of this patient having extracapsular disease. In combination with the unknown date of the biopsy, it would be prudent to exclude the possibility that this low signal in the seminal vesicles is not haemorrhage by repeating the scan. If this does represent disease invasion of the seminal vesicles, then it would indicate T3b disease.

Partin A, Kattan M, Subong E, Walsh P, Wojno K, Oesterling J et al. Combination of prostate-specific antigen, clinical stage, and Gleason score to predict pathological stage of localised prostate cancer. A multi-institutional update. *Journal of the American Medical Association* 1997; 277: 1445-1451.

40.A. Krukenberg tumours.

The history points towards a GI source, namely gastric carcinoma. Approximately 5-15% of ovarian tumours are metastatic lesions. They are bilateral in 75% of cases. They are often asymptomatic and may present before the primary tumour. They should be considered, along with serous epithelial tumours of the ovary, when bilateral complex ovarian masses are demonstrated. Krukenberg tumours represent ovarian metastases that contain mucin-secreting 'signet-ring' cells from colonic or gastric neoplasms. Other primary neoplasms that less commonly metastasize to the ovary are breast, lung, and the contra-lateral ovary (not strictly Krukenberg tumours due to the cell types). Imaging findings in metastatic lesions are non-specific, consisting of predominantly solid components or a mixture of cystic and solid areas. In Krukenberg tumours, there are distinctive findings, including solid components secondary to stromal reaction that are low T2WI and high T1W signal.

A Sertoli-Leydig tumour is a sex cord-stromal tumour that occurs in young women (less than 30 years old). It manifests as a well-defined, enhancing solid mass with intra-tumoral cysts. They constitute 0.5% of ovarian tumours. They are rarely bilateral.

Dysgerminomas are rare ovarian tumours that occur predominantly in young women. Serum β -HCG is increased in 5%. Calcification may be present in a speckled pattern. Characteristic imaging findings include multilobulated solid masses with prominent fibrovascular septa. They are rarely if ever bilateral.

Fibromas are benign solid tumours of the ovary, which are of low signal on T1W and very low signal on T2W sequences. They can be associated with ascites and pleural effusions (Meigs syndrome), and dense calcifications are often seen. Together with fibrothecomas they form a spectrum of benign tumours.

Endodermal sinus tumour, also known as yolk sac tumour, is a rare malignant ovarian tumour that usually occurs in the second decade of life. These tumours manifest as a large, complex pelvic mass that extends into the abdomen and contains both solid and cystic components. They are rarely bilateral. They grow rapidly and have a poor prognosis. Affected patients have an elevated serum alpha feta protein.

Hamm B and Forstner R (eds). *MRI and CT of the Female Pelvis*. Springer, 2007, p. 259.

Jung SE, Lee JM, Rha SE, Byun JY, Jung JI, and Hahn ST. CT and MR imaging of ovarian tumors with emphasis on differential diagnosis. *Radiographics* 2002; 22: 1305-1325.

41. C. A relative percentage washout (RPW) of 60%.

Findings consistent with an adrenal adenoma are: a pre-contrast attenuation of 10 HU or less, an absolute percentage washout (APW) of 60% or greater, or an RPW of 40% or greater. The percentage washout is calculated by comparing the attenuation value at 15 minutes post contrast (delayed H), to the value in the portal venous phase (enhanced H), and in the case of APW, the pre-contrast value.

$$RPW = 100 \times (\text{enhanced H} - \text{delayed H}) / \text{enhanced H}$$

$$APW = 100 \times (\text{enhanced H} - \text{delayed H}) / (\text{enhanced H} - \text{pre-contrast H})$$

In practice, an unenhanced scan is not usually performed and thus only the RPW is calculated.

Adrenal cortical carcinomas usually have an RPW of less than 40% although exceptions have been reported. Their large size (usually greater than 6 cm), heterogeneously pre-contrast (necrosis), and heterogeneous enhancement are more reliable indicators of the diagnosis. Phaeochromocytomas and hypervascular metastases may mimic adenomas, but most metastases show $RPW < 40\%$ and $APW < 60\%$.

Johnson PT, Horton KM, and Fishman EK. Adrenal mass imaging with multidetector CT: pathologic conditions, pearls, and pitfalls. *Radiographics* 2009; 29: 1333–1351.

42. A. Coagulation necrosis.

HIFU is a non-invasive method to treat solid tumours or haemorrhage. As HIFU is essentially ultrasound, it requires an acoustic window to transmit ultrasound energy and is subject to similar artefact. The principle effect of HIFU is heat generation from absorption of acoustic energy. This causes coagulation necrosis within seconds. Hyperthermia also induces apoptosis, which can be an important delayed effect in tissue exposed to lower energy HIFU. This mechanism is also a potential limitation of HIFU as adjacent tissue may be at risk. Mechanical effects such as cavitation and microstreaming are also seen with the use of higher ultrasound intensity.

Dubinsky TJ, Cuevas C, Dighe MK, Kolokythas O, and Hwang JH. High-intensity focused ultrasound: current potential and oncologic applications. *American Journal of Roentgenology* 2008; 190: 191–199.

43. B. Architectural distortion.

ILC is the second most common form of invasive breast cancer; after ductal carcinoma. It exhibits the same mammographic features as invasive ductal carcinoma, although architectural distortion is the most common mammographic finding. Due to the pattern of small cells growing around ducts ('Indian files'), mammographic findings are subtle and thus ILC is the most frequently missed breast cancer. Prognosis is generally poor due to late diagnosis.

Dahner W. *Radiology Review Manual*, 6th edn, Lippincott Williams & Wilkins, 2007, p. 558.

44. D. Double decidual sac sign.

All the other answers are findings in the uterus that may be associated with ectopic pregnancy. In normal pregnancies, TVUS can demonstrate an intradecidual sign approximately 4.5 weeks after the last menstrual period. The intradecidual sign is a small collection of fluid that is eccentrically located within the endometrium and is surrounded by a hyperchoic ring. At approximately 5 weeks, the double decidual sac sign can be visualized. This consists of two concentric hyperechoic rings that surround an anechoic gestational sac in a normal intrauterine pregnancy. The secondary yolk sac may be identified at TVUS at approximately 5.5 weeks. Embryonic cardiac

activity should also be visualized at TVUS at approximately 5–6 weeks, when the gestational sac measures at least 18 mm or when the embryonic pole measures at least 5 mm.

A pseudogestational sac is a thick decidual reaction surrounding intrauterine fluid and is seen in approximately 10% of ectopic pregnancies. A trilaminar endometrium is formed during the late proliferative phase of the menstrual cycle. When an abnormal pregnancy is suspected on the basis of laboratory results, the absence of a true gestational sac in the presence of a trilaminar endometrium is highly suggestive of ectopic pregnancy. Thin-walled decidual cysts are seen at the junction of endometrium and myometrium, and may be seen in both normal and abnormal pregnancies. The thin wall differentiates it from a true gestational sac.

Lin EP, Bhatt S, and Dogra V. Diagnostic clues to ectopic pregnancy. *Radiographics* 2008; 28: 1661–1671.

45. E. All of them.

MRI is not a primary investigation in the diagnosis of prostate cancer but it is used in staging known disease. Occasionally, in a patient with a high risk of prostate carcinoma, as in this case, when the urologists have repeatedly failed biopsies, MRI can be used to help guide biopsy. In this setting, MRI can also be used to increase confidence in the diagnosis. As with all prostate imaging for cancer, the results are more reliable in the peripheral zone due to the variability of appearances in the transitional zone. Choline is elevated in prostate cancer, and is thought to reflect increased cell membrane turnover. Creatine, also detected on MRS, is unchanged. Polyamine is reduced. Citrate, which is stored in normal prostatic cells, is reduced, presumably because of reduced normal function within cancerous cells. The (creatine + choline)/citrate ratio has been used to help discriminate prostate cancer from normal prostate. The role of MRS in the transitional zone is unclear.

Fuchsjager M, Shukla-Dave A, Akin O, Barentsz J, and Hricak H. Prostate cancer imaging. *Acta Radiologica* 2008; 49(1): 107–120.

46. A. Hypovolaemic shock.

Marked adrenal enhancement may be the only sign of significant hypovolaemic shock. This is thought to be due to hyperperfusion of the adrenal glands because of their crucial role in this clinical situation. Other signs that may accompany this sign, the 'hypoperfusion complex' described in shock due to trauma, are collapsed IVC, small hypodense spleen, small aorta and mesenteric arteries, shock nephrogram (lack of renal contrast excretion), intense pancreatic enhancement, dilatation of fluid-filled intestine with thickening of folds, and increased enhancement of the wall. However, in cases of hypovolaemic shock due to sepsis, where there has been rapid fluid replacement, the IVC and aorta may be of normal calibre and persisting marked adrenal enhancement has been described as the only abnormality.

Phaeochromocytomas are bilateral in only approximately 10% and this would be even less likely in the presence of another neoplasm. Hypervascular metastases are uncommon in colon carcinoma. Adrenal hyperplasia may occur as a response to stress but the adrenals would enhance normally. In tuberculous adrenalitis, the adrenal glands show areas of necrosis and sometimes calcification, with possible rim enhancement. In all four of these alternative options the adrenal glands would be enlarged.

Cheung SCW, Lee R, Tung HKS, and Chan FL. Persistent adrenal enhancement may be the earliest CT sign of significant hypovolaemic shock. *Clinical Radiology* 2003; 58: 315–318.

Dahner W. *Radiology Review Manual*, 5th edn. Lippincott Williams & Wilkins, 2003, p. 872.

Wang YX, Chen CR, He GX, and Tang AR. CT findings of adrenal glands in patients with tuberculous Addison's disease. *Journal Beige de Radiologie* 1998; 81: 226–228.

47. D. Ovarian dysfunction.
Ovarian dysfunction is a known complication of fibroid embolization. The exact mechanism is not known, but inadvertent embolization of the ovaries via a uterine-ovarian anastomosis has been suggested. There is a higher prevalence of uterine-ovarian anastomosis in women over 45 years of age and that puts them at increased risk.
Kitamura Y, Ascher S, Cooper C, Allison SJ, Jha RC, Flick PA et al. Imaging manifestations of complications associated with uterine artery embolization. *Radiographics* 2005; 25: S119–S132.

48. B. Ultrasound guided needle aspiration.
Breast abscess is a potential complication of mastitis that may occur during breast-feeding, particularly in primiparous women. *Staphylococcus aureus* is the most common causative organism. Treatment of mastitis usually consists of breast-emptying procedures and antibiotics. Abscesses are difficult to detect clinically and so the patient should be investigated via ultrasound if mastitis does not promptly respond to appropriate therapy. Ultrasound-guided needle aspiration is a suitable method of treatment for abscesses less than 3 cm in maximum diameter. Continuing breast-feeding is not felt to be problematic.
Ullitsch D, Nyman MKG, and Carlson RA. Breast abscess in lactating women: US-guided treatment. *Radiology* 2004; 232: 904–909.

49. E. 60 pre-contrast attenuation, 70 post-contrast attenuation.
The attenuation of the normal renal parenchyma typically ranges from 30 to 40 HU. That of hyperattenuating renal masses usually is at least 40 HU but no higher than 90 HU on CT without intravenous contrast. Benign cysts are overwhelmingly the most common type of hyperattenuating renal mass and are also known as hyperdense renal cysts. They are usually cysts containing haemorrhage or proteinaceous material. Hyperattenuating cysts should not enhance and therefore cannot be diagnosed with confidence by using unenhanced CT alone. A proper CT examination includes scanning both before and after the administration of intravenous contrast material. Masses that increase in attenuation by 10 HU or less are considered non-enhancing. Masses that increase in attenuation by more than 10 HU are considered enhancing. However, because the standard deviation of attenuation measurements may be more than 10 HU, an attenuation difference of 20 HU or more is a more specific criterion of enhancement.
Silverman SG, Morfele KJ, Tuncali K, Jinzaki M, and Cibas ES. Hyperattenuating renal masses: etiologies, pathogenesis, and imaging evaluation. *Radiographics* 2007; 27: 1131–1143.

50. C. Perinephric and perireticular stranding.
Whilst this observation is sensitive and specific for detecting calculi, it does not have a bearing on stone outcome or urgency of treatment. The site is of value because if the stone impacts, it dictates the therapeutic approach. The size of the calculus can be used to assess the likelihood of spontaneous passage, with calculi over 5 mm more likely to cause obstruction. The density of the calculus has been found to predict the success of extracorporeal shock wave lithotripsy (ESWL). The presence of anatomical variations is also of interest to the urologists in treatment planning, if this becomes necessary.
Sandhu C, Anson K, and Patel U. Urinary tract stone – Part 1: Role of radiological imaging in diagnosis and treatment planning. *Clinical Radiology* 2003; 58: 415–421.

51. C. Uterine leiomyomas.

Also known as uterine fibroids, these are very common. They are usually of low signal on T2WI and intermediate signal on T1WI. Benign metastasizing leiomyoma is an unusual variant, with tumours in the lungs, lymph nodes, or peritoneal nodules, not uncommonly from a benign uterine

fibroid, which has been removed many years earlier. Malignant transformation to leiomyosarcoma is very rare and it is thought the latter may arise de novo even in the presence of leiomyomas. Endometrial sarcoma might produce peritoneal metastases, but would be expected to show a large heterogeneous mass with indistinct or irregular borders arising from the endometrial canal. Endometriosis and adenomyosis are diseases of the reproductive years. Metastases to the uterus are rare and if present represent advanced malignancy. There is usually diffuse enlargement of the myometrium, which can be of low or high signal.

Martin D, Brown M, and Semelka R. *Primer on MR Imaging of the Abdomen and Pelvis*. Wiley, 2005, 437-439.

Szklaruk J, Tamm EP, Choi H, and Varavithya V. MR imaging of common and uncommon large pelvic masses. *Radiographics* 2003; 23: 403-424.

52. C. Vesico-ureteric reflux.

The abnormality described on ultrasound is multicystic dysplastic kidney (MCDK). It is the most common form of cystic disease in infants and the second most common cause of an abdominal mass in a neonate (after hydronephrosis). Obstruction/atresia of the ureter during the developmental stage is thought to be the etiology.

Bilateral MCDK is uncommon, but associated anomalies of the contra-lateral kidney are seen in up to 50% of cases. Vesico-ureteric reflux (30-40%) is the most common associated anomaly, followed by pelvi-ureteric junction obstruction (10-20%).

Mercado-Deane M-G, Beeson JE, and John SD. US of renal insufficiency in neonates. *Radiographics* 2002; 22: 1429-1438.

Dahner W. Multicystic dysplastic kidney, in *Radiology Review Manual*, 6th edn, Lippincott Williams & Wilkins, 2007, pp. 937-938.

53. C. Deep laceration to the collecting system.

Renal injuries are classified into five grades of severity by the American Association for the Surgery of Trauma (AAST), with approximately 80% classified as grade 1 (Table 4.1). Most significant injuries manifest as haematuria and no significant urinary tract injury occurs in the absence of gross haematuria and shock. In addition, most significant renal trauma is associated with additional visceral injury.

Table 4.1 AAST grading of renal trauma

Grade	Injury
1	Parenchymal contusion
2	Isolated subcapsular haematoma
	Superficial cortical laceration < 1 cm
3	Non-expanding perirenal haematoma
	Laceration > 1 cm without extension to collecting system
4	Deep laceration to collecting system
	Segmental infarctions without associated lacerations
5	Injury to main renal artery without devascularization
	Shattered kidney
	Ureteropelvic junction avulsion
	Devascularization to renal pedicle

54. C. Repeat CT in 3–6 months.

Solid masses smaller than 1 cm are challenging. Firstly, there is a reasonable chance that a very small solid mass is benign. Secondly, it is often difficult to characterize a mass smaller than 1 cm as solid and enhancing, despite a meticulous technique using state-of-the-art CT and MR imaging. Thirdly, these masses are often too small to biopsy, therefore when encountering a mass that is believed to be solid and is less than 1 cm in size, it is reasonable to observe them with an initial examination with CT or MR at 3–6 months followed by yearly examinations. A full work-up could ensue when the mass reaches 1 cm in size.

Silverman SG, Israel GM, Herts BR, and Richie JP. Management of the incidental renal mass. *Radiology* 2008; 249: 16–31.

55. B. Bladder calcification.

Whilst this can be seen in TB, it is more typically associated with schistosomiasis. TB usually causes scarring and a reduced capacity bladder. Renal calcification is typical. The areas of increased attenuation within the calyceal system represent areas of coalescing caseating granulomas, and may have associated calcification. Scarring can also cause stenosis of calyces, causing focal obstruction. Occasionally a small calcified kidney is found, evidence of autonephrectomy. Passage of the infection via the urine into the ureters causes focal stenoses, which can coalesce to cause a long stricture, or give a beaded or corkscrew appearance to the ureter. Whilst renal TB results from spread from a primary pulmonary infection, the CXR is only abnormal in 25–50% of cases and is therefore not helpful.

Gibson M, Puckett M, and Shelly M. Renal tuberculosis. *Radiographics* 2004; 24: 251–256.

56. B. Multiple small peripheral rounded high T2WI signal areas with hypointense central stroma

in both ovaries.

The clinical features suggest polycystic ovarian syndrome (PCOS). The diagnosis is based on hormonal imbalance and patients often show an abnormality in the ratio of luteinizing hormone to follicle stimulating hormone. The MRI findings are those described, with multiple small peripheral cysts with low signal central stroma. MRI is not specific or sensitive, and 25% of patients with PCOS can have normal appearing ovaries. Multiple small, T2WI hypointense cysts have been seen in patients with anovulation, medication-stimulated ovulation, or vaginal agenesis. The other descriptions are associated with infertility, but not particularly hirsutism or obesity. Option A describes bilateral hydrosalpinx. Option D describes a unicornuate uterus, which is associated with the poorest foetal survival among all uterine anomalies. Option E describes adenomyosis and using a junctional zone thickness of 12 mm or above optimizes the accuracy of MRI for this diagnosis.

Imaoka I, Wada A, Matsuo M, Yoshida M, Kitagaki H, and Sugimura K. MR imaging of disorders associated with female infertility: use in diagnosis, treatment, and management. *Radiographics* 2003; 23: 1401–1421.

57. B. Wilms tumor.

Sporadic aniridia is associated with nephroblastomatosis (multiple nephrogenic rests) and an increased risk of Wilms tumor. At CT, the nephrogenic rests appear as homogeneous, hypodense nodules/peripheral rim, with little or no enhancement compared to the compressed normal cortical tissue.

Any new, enlarging, or heterogeneous mass in the setting of nephroblastomatosis indicates the development of a Wilms tumor.

Sethi AT, Das Narla L, Fitch SJ, and Frable WJ. Wilms tumor in the setting of bilateral nephroblastomatosis. *Radiographics* 2010; 30: 1421–1425.

The normal endometrial stripe is of high T2WI signal and measures 3–6 mm in diameter in the follicular phase and 5–13 mm in the secretory phase. The description of the endometrium in this case is consistent with endometrial hyperplasia, but there is in addition myometrial enlargement. An enlarged uterus is frequently encountered in the presence of endogenous or exogenous hormonal abnormalities. In these cases the uterus usually has normal zonal anatomy, although the signal intensity of the endometrium and myometrium is abnormally increased. However, with tamoxifen, the uterus can display marked zonal anatomy distortion. It is a weak oestrogen agonist and can result in endometrial hyperplasia, polyps, and carcinoma. The findings of multiple cysts or lattice-like enhancement of the endometrium post contrast are encountered frequently in relation to tamoxifen therapy and favour a benign diagnosis.

61. B. Tamoxifen therapy.

Sandhu C, Anson K, and Patel U. Urinary tract stone – Part 1: Role of radiological imaging in diagnosis and treatment planning. *Clinical Radiology* 2003; 58: 415–421.

CT KUB. Calcium and urate calculi are classically not detectable on plain film KUB, but are usually visible on and chronic dehydration with calcium oxalate calculi, both of which are radio-opaque. Xanthine therapy can be undetectable even to CT. Proteus is associated with formation of staghorn calculi whilst CT KUB has 95–99% sensitivity for renal calculi, occasionally calculi due to antiretroviral therapy. HIV-positive patient on antiretroviral therapy.

Radiology 2008; 249: 16–31.

Silverman SC, Israel GM, Herts BR, and Richie JP. Management of the incidental renal mass.

expectancy, when they may be observed. Thickened irregular or smooth walls or septa, with measurable enhancement, are features of a Bosniak III cyst and these are surgical lesions unless there are co-morbidities or limited life (<3 cm) that are sharply margined and do not enhance. The criteria for a Bosniak II cyst that does not require follow-up include few hairline-thin septa or slightly thickened calcification in the wall or septa, homogeneously high-attenuating masses with or without perceived (not measurable) enhancement, fine calcification or a short segment of slightly thickened calcification in the wall or septa, minimal enhancement, calcification may be thick and nodular but no measurable enhancement present, no enhancing soft-tissue components, and intrarenal non-enhancing high-attenuation renal mass (>3cm). The follow-up is CT or MRI at 6 months, 1 year, and then yearly up to 5 years. The criteria for a Bosniak IIF cyst are multiple hairline-thin septa with or without perceived (not measurable) enhancement, minimal smooth thickening of wall or septa that may show perceived enhancement, calcification may be thick and nodular but no measurable enhancement present, no enhancing soft-tissue components, and intrarenal non-enhancing high-attenuation renal mass (>3cm). The follow-up is CT or MRI at 6 months, 1 year, and then yearly up to 5 years. The criteria for a Bosniak III cyst are surgical lesions unless there are co-morbidities or limited life expectancy, when they may be observed.

59. C. Multiple thin non-enhancing septa.

Harris AC, Zwirowich CV, Lyburn ID, Torregiani WC, and Marchinkow LO. CT Findings in blunt renal trauma. *Radiographics* 2001; 21: S201–S214.

of the main renal artery. The cortical rim nephrogram is a sign of a devascularized kidney, which occurs due to laceration phase indicates active extravasation. Intense enhancement within a laceration during the early examination indicates the presence of a urine leak. A delayed scan of 10–15 minutes may show with intravenous contrast. Contrast enhancement during the pyelographic phase of the CT Lacerations generally contain clotted blood and therefore do not enhance on scans obtained

58. E. Urine leak.

IUCDs are widely used for contraception. A study has found that the IUCD-bearing uterus is enlarged. IUCD placement most likely results in myometrial hypertrophy. The associated findings are symmetrical globular enlargement of the uterine corpus, cervical elongation and enlargement, and diffuse or localized myometrial thickening. The IUCD will usually be seen as a band of low signal intensity within the endometrium.

The uterus is rarely the primary site for lymphoma, but when it does occur, the most common manifestation is diffuse symmetrical uterine enlargement with relatively high signal on T2WI and epithelial preservation: the endometrium is usually normal. The myometrium will also lack its standard zonal appearance. There will almost always be associated lymphadenopathy.

Endometrial stromal sarcoma invariably exhibits myometrial involvement. Imaging will typically show a large mass that replaces the endometrial cavity and infiltrates the myometrium; at the very least the endometrial-myometrial border will be obscured. Myometrial involvement is commonly so extensive that a myometrial component predominates. Bands of low signal may be present within the area of myometrial invasion and these correspond to preserved bundles of myometrium at histologic examination. Extension along the vessels, fallopian tubes, or ligaments is another characteristic of the tumour.

Pelvic congestion syndrome involves symptoms, including chronic pelvic pain, that are associated with dilated ovarian veins and pelvic varices resulting from left renal vein reflux. This results in a thickened myometrium containing multiple large signal voids, the latter corresponding to engorged arcuate vessels. Additional findings include varicose veins around the uterus and ovaries with retrograde filling of ovarian veins.

Kido A, Togashi K, Koyama T, Toshihide Y, Fujiwara T, and Fujii S. Diffusely enlarged uterus: evaluation with MR imaging. *Radiographics* 2003; 23: 1423-1439.

62. C. Ablation zone unchanged in size over time.

Following ablation the treatment zone is larger than the original lesion, as a margin of normal tissue is intentionally ablated to prevent recurrence. This should reduce in size/involve over time. If the ablation zone remains the same or increases in size, recurrence should be suspected. Lack of enhancement is a reliable indicator of successful treatment. It is not uncommon to find peripheral enhancement in the immediate post-treatment period due to reactive hyperaemia. Any nodular or central enhancement indicates incomplete treatment or recurrence. Allen BC and Renner EM. Percutaneous cryoablation of renal tumors: patient selection, technique, and postprocedural imaging. *Radiographics* 2010; 30: 887-900.

63. A. Anterior urethral injury.

Urethral injuries are rarely life-threatening but have significant long-term morbidity. Complications include stricture, incontinence, and impotence. The male urethra extends from the bladder base to the external meatus and is divided into the posterior (prostatic and membranous) and anterior (bulbous and penile) urethra. The anterior and posterior urethra are separated by the urogenital diaphragm. The Goldman classification of urethral injury emphasizes anatomic location (Table 4.2).

Table 4.2 The Goldman classification of urethral injury

Type	Injury description	Urethrographic appearance
I	Stretching of an intact posterior urethra	Intact but stretched urethra
II	Urethral disruption above the urogenital diaphragm, membranous segment intact	Contrast extravasation above the urogenital diaphragm only
III	Disruption of membranous urethra extending to anterior urethra	Contrast extravasation below the urogenital diaphragm possibly extending to the perineum
IV	Bladder neck injury extending into the proximal urethra	Extraperitoneal contrast extravasation, bladder neck disruption
IVa	Bladder base injury simulating type IV	Bladder base disruption, periurethral contrast extravasation
V	Isolated anterior urethral injury	Contrast extravasation below the urogenital diaphragm

Data from Goldman SM, Sandler CM, Corriere JN, and McGuire EJ. Blunt urethral trauma: anatomical mechanical classification. *Journal of Urology* 1997; 157: 85–89.

Ingram MD, Watson SG, Skippage PL, and Patel U. Urethral injuries after pelvic trauma: evaluation with urethrography. *RadioGraphics* 2008; 28: 1631–1643.

64. D. Maintenance of reniform shape.

Advanced TCC of the collecting system in the kidney can cause distortion of the renal architecture, but typically the reniform shape of the kidney is maintained. As RCC arises in the renal cortex, large tumours of this nature typically distort the normal renal outline.

Calcification can rarely occur in both RCCs and TCCs, although perhaps more commonly in RCC. TCC demonstrates calcification in less than 3%, when it is usually diffuse and punctate.

Necrosis can occur in both large RCCs and large TCCs, giving a heterogeneous enhancement pattern on CT. Renal vein invasion is a more typical manifestation of RCC and both these

tumours may be hypovascular compared to normal renal parenchyma on a nephrographic phase of the CT examination.

Browne RFJ, Meehan CP, Colville J, Power R, and Torregiani WC. Transitional cell carcinoma of the upper urinary tract: spectrum of imaging findings. *RadioGraphics* 2005; 25: 1609–1627.

Anderson EM, Murphy R, Rennie ATM, and Cowan NC. Multidetector computed tomography urography (MDCTU) for diagnosing urothelial malignancy. *Clinical Radiology* 2007; 62: 324–332.

65. C. Chronic non-steroidal anti-inflammatory drug (NSAID) analgesic overuse.

The appearances described are those of renal papillary necrosis. This can be due to a number of causes, most commonly analgesic abuse, but also severe renal infection in diabetics, sickle cell disease, haemophilia, and renal vein thrombosis. The causes of chronic renal disease can be subdivided by the effects noted on the renal parenchyma and the papillary/pelviccalyceal system, and whether these are uni- or bilateral. In bilateral cases such as this, no radiological abnormality suggests possible glomerulonephritis, acute tubular necrosis (ATN), acute cortical necrosis, or pyelonephritis. Generalized infiltration of the renal parenchyma suggests amyloid or malignant infiltration (e.g. lymphoma or leukaemia). Papillary/pelviccalyceal abnormalities, in the presence of normal parenchyma, indicate papillary necrosis, medullary sponge kidney, or renal TB. Papillary calyceal abnormality with focal parenchymal loss indicates reflux nephropathy, TB, or calculus. Both parenchymal loss and papillary calyceal abnormalities indicate obstructive nephropathy or severe reflux nephropathy.

66. D. Minimal deviation adenocarcinoma of the cervix.

This is also known as adenoma malignum and, as in this scenario, is often associated with Peutz-Jeghers syndrome (characterized by mucocutaneous pigmentation, multiple hamartomatous polyps of the GI tract, and mucinous tumours of the ovary). Adenoma malignum makes up about 3% of adenocarcinoma of the cervix. Its MRI appearances are as described in the question, but the differential diagnosis includes deep nabothian cysts, florid endocervical hyperplasia, and even well-differentiated adenocarcinoma. It disseminates into the peritoneal cavity even in the early stage of the disease and its response to radiation or chemotherapy is poor.

Cervical squamous carcinoma makes up to 90% of cervical carcinoma. The tumour is of high signal compared to the hypointense cervical stroma, but not cystic as in our vignette. It advances predominantly by direct extension and local spread; haematogenous dissemination is only occasionally seen in the form of hepatic metastases.

Carcinoid tumour of the cervix is a subgroup of small cell carcinoma of the cervix. It cannot be differentiated from squamous cell carcinoma of the cervix on MRI findings.

Malignant melanoma of the female genital tract accounts for 1–5% of all melanomas. It usually occurs in the vaginal mucosa and occasionally involves the cervix. Malignant melanoma arising in the cervix is very rare (only about 30 reported cases). There is usually high signal intensity on T1WI.

The incidence of cervical pregnancy has been increasing, possibly due to the increased number of induced abortions. Reported risk factors include multiparity, prior cervical surgical manipulation, cervical or uterine leiomyomas, atrophic endometrium, and septate uterus. The major symptom is painless vaginal bleeding. At MRI it is characterized by a mass with heterogeneous signal intensity and a partial or complete dark ring on T2WI sequences. As it contains haematoma, it often consists of some high signal on T1WI.

Okamoto Y, Tanaka YO, Nishida M, Tsunoda H, Yoshikawa H, and Imai Y. MR imaging of the uterine cervix: imaging-pathologic correlation. *Radiographics* 2003; 23: 425–445.

67. A. Cervical carcinoma.

This patient has developed lymphangitis carcinomatosa. In 50% of cases the septal thickening is focal or unilateral and this is useful in distinguishing lymphangitis from other causes of septal thickening, such as pulmonary oedema or sarcoidosis. Hilar adenopathy is present in 50% and pleural effusion in 30–50%. The interlobular septal thickening can be smooth (as in pulmonary oedema and alveolar proteinosis) or nodular (also found in sarcoidosis and silicosis).

Lymphangitis carcinomatosa usually occurs secondary to the spread of (adeno-) carcinoma, most commonly bronchogenic, breast, and stomach. The mnemonic **Cervical Carcinoma Spread By Plugging The Lymphatics (Cervix Colon Stomach Breast Pancreas Thyroid Larynx)** is useful. Lymphangitis carcinomatosa is occasionally associated with cervical carcinoma and certainly more so than with the other options presented.

Dahner W. *Radiology Review Manual*, 5th edn, Lippincott Williams & Wilkins, 2003, p. 502.

68. C. Adenomyosis.

This is a condition in which the endometrium extends into the myometrium in either a diffuse or a focal distribution. It generally manifests as pelvic pain or abnormal bleeding. It is more commonly detected on MRI imaging as thickening of the junctional zone or on ultrasound as diffuse or focal heterogeneous myometrium. On HSG, adenomyosis appears as small diverticula extending from the endometrial cavity into the myometrium.

Salpingitis isthmica nodosa appears as small outpouchings from the isthmus portion of the fallopian tube.

Multiple uterine synechiae (linear filling defects in the uterine cavity) associated with infertility is known as Asherman syndrome. Polyps would appear as filling defects on HSG. Simpson Jr WL, Beitia LG, and Mester J. Hysterosalpingography: a reemerging study. *Radiographics* 2006; 26: 419–431.

69.A. Uterus didelphys.

This is caused by complete failure of fusion of the paramesonephric ducts, resulting in a completely duplicated system (two uterine cavities and two cervixes) with no communication between the two cavities. It is associated with complete or partial vaginal septum in 75% of cases, which can result in obstruction and haematometocolpos. Ipsilateral renal agenesis is associated with a vaginal septum. Bicornuate uterus is caused by partial fusion of the paramesonephric ducts. Bicornuate bicornis uteris demonstrates a septum extending from the fundus to the external os, but some degree of communication remains between the two horns.

Septate uterus is the most common müllerian/paramesonephric duct anomaly. It is also the most common anomaly associated with infertility and recurrent miscarriage. A complete or partial septum divides the uterine cavity, but there is no fundal cleft. Arcuate uterus is associated with a small indentation in the fundal endometrial canal but the external contour is normal. It has no pathological consequence and is considered by some to be a normal variant.

Junqueira BLP, Allen LM, Spitzer RF, Lucio KL, Babyn PS, and Doria AS. Müllerian duct anomalies and mimics in children and adolescents: correlative intraoperative assessment with clinical imaging. *Radiographics* 2009; 29: 1085–1103.

70.C. Extraperitoneal rupture.

Over 70% of patients with traumatic bladder injury have a coexisting pelvic fracture. CT cystography is considered to be as accurate as conventional cystography. Extraperitoneal rupture accounts for 80% of all cases of traumatic bladder injury. It occurs as a result of shearing forces or penetrating injury from bony fragments at the base of the bladder. Contrast can also track down into the scrotum or thigh. Intraperitoneal rupture (15% of cases) follows a direct blow to a distended bladder, with the tear involving the bladder dome. Contrast will be seen to outline small bowel loops. Combined injuries occur in 5%. Interstitial injuries are rare and are detected by contrast dissecting into the bladder wall. Imaging is frequently normal in the setting of bladder contusion.

Bent C, Lyngkaran T, Power N, Matson M, Hajdinjak T, Buchholz N et al. Urological injuries following trauma. *Clinical Radiology* 2008; 63: 1361–1371.

71.E. Focus of increased radionuclide activity within the lower pole of the right lobe of thyroid on delayed images only.

Solitary parathyroid adenoma accounts for 85% of cases of primary hyperparathyroidism, with parathyroid hyperplasia (10%), multiple adenomas (4%), and carcinoma (1%) making up the remainder. When $^{99m}\text{Tc MIBI}$ is used for parathyroid imaging, immediate and delayed images of the neck and mediastinum are performed. Parathyroid adenomas may or may not be visualized on initial imaging, but they retain radiopharmaceutical on delayed (1–2 hours) images, whereas the normal thyroid washes out.

Brant WF and Helms CA. *Fundamentals of Diagnostic Radiology*, 3rd edn, Lippincott Williams & Wilkins, 2007, pp. 1412–1414.

72.A. Localized cystic renal disease.

This is an uncommon, non-familial, and non-progressive disorder of the kidney characterized by the replacement of all or localized areas of a kidney by multiple variably sized cysts. These cysts form clusters that are separated by thin areas of normal renal parenchyma. The aggregated cysts in localized cystic disease can frequently appear like a multi-septate mass, but they do not form a distinct encapsulated mass and do not show mural irregularities, which are characteristics of cystic neoplasms.

Multilocular cystic nephroma in adults is much more common in females (female:male 9:1) and manifests as a multi-located cystic lesion with hair-like septa and minimal mural enhancement. It is distinguished from localized cystic disease by the presence of a capsule. Typically extension into the central renal sinus is found and multilocular cystic nephroma is often classified on imaging as Bosniak III lesions.

Lymphangioma of the kidney is a rare benign cystic tumour that most often arises from the peripelvic region or renal sinus. It may more rarely arise from the lymphatics of the capsule or cortex. In the diffuse form of lymphangiomatosis, the cystic changes occur diffusely in the renal sinus or peripelvic region, with a relatively normal appearing renal parenchyma. Clear cell RCC presents as a solid or a cystic lesion, the cystic variant accounting for 4–15% of all RCCs. These lesions typically have nodular or septal enhancement, distinguishing them from benign cystic renal lesions.

Multicystic dysplastic kidney is a congenital maldevelopment in which the kidney is completely replaced by cysts with no normal renal parenchyma remaining.

Feire M and Remer EM. Clinical and radiological features of cystic renal masses. *American Journal of Roentgenology* 2009; 192: 1367–1372.

73.D. Refer for immediate venous intervention.

There are a number of complications to be aware of in the immediate post-transplant period. The most efficient and cost-effective method of surveillance for these is ultrasound. Acute rejection and acute tubular necrosis (ATN) both occur early in the post-transplant phase and can be difficult to differentiate. Both can cause elevation of pulsatility index (PI) (normal <1.5) and resistive index (RI) (normal <0.7), although these tend to be higher with rejection. ATN is more common with cadaveric transplants. It usually resolves within a matter of days or weeks, but ultimately biopsy can be necessary to reliably differentiate these processes. This patient probably had a degree of ATN initially. Arterial occlusion is uncommon and is evident by reduced/absent arterial flow in the main artery as well as in the interlobar arteries, which can demonstrate loss of flow with any cause of severe oedema (e.g. renal vein thrombosis or acute rejection). Renal vein thrombosis causes pain and anuria. It is associated with early treatment with cyclosporine and steroids. It also causes a rise in the RI and PI. The key feature to notice is the persistent flow in the main renal artery, reducing the likelihood of renal arterial thrombosis. There is also a tubular structure noted in the hilum, which is what a thrombosed renal vein looks like, and reversal of diastolic flow on arterial traces.

Baxter G. Ultrasound of renal transplantation. *Clinical Radiology* 2001; 56(10): 802–818.

Sandhu C and Patel U. Renal transplantation dysfunction: the role of interventional radiology. *Clinical Radiology* 2002; 57(9): 772–783.

74.B. PI < 1.5, RI < 0.7, prominence of renal pyramids.

PI < 1.5 or RI < 0.7 can be regarded as normal, whilst a PI > 1.8 or RI > 0.9 should be regarded as abnormal. Although both ATN and acute rejection cause the PI and RI to rise, the likelihood of acute rejection is greater with higher values. Complete absence of diastolic flow, or flow reversal, is due to acute rejection in the majority of cases.

Morphologically, the transplant kidney is very similar to the native and many of the subtle differences are attributed to the improved resolution of the former. There is a well-defined renal parenchyma peripherally, with a highly reflective echogenic sinus centrally, in distinction to the native kidney, the renal pyramids are more commonly visualized within the transplant, being hypoechoic, relative to the parenchyma itself.

Loss of cortico-medullary differentiation is pathological and is a B mode finding that can be associated with acute rejection.

Baxter GM. Pictorial review: ultrasound of renal transplantation. *Clinical Radiology* 2001; 56: 802-818.

75. B. Endometriotic cyst.

Also known as a chocolate cyst, the methaemoglobin within the lesion causes T1 shortening, resulting in increased signal on the T1WI sequence. This high signal remains and becomes more conspicuous on the T1WI with fat saturation sequence.

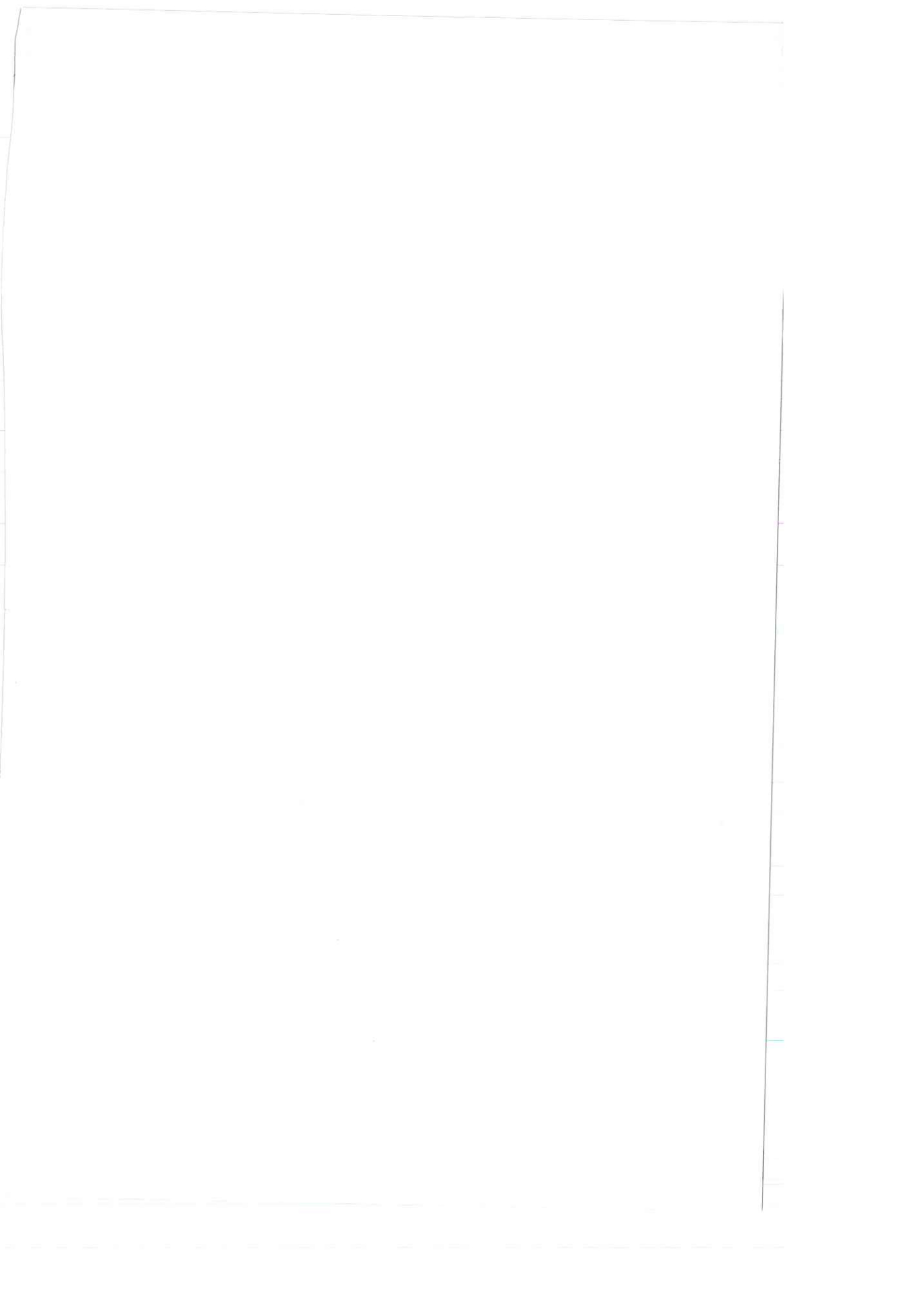
Endometriosis is characterized by the presence of tissue resembling endometrium outside the uterus. The ovaries are the most commonly involved site, and endometriotic cysts usually have a thick fibrotic wall with chocolate-coloured hemorrhagic material. An endometriotic cyst may be high or low signal on T2WI sequences. Chronic cyclical haemorrhage and increased viscosity of the cyst material will produce T2 shortening, leading to the low signal, or 'T2 shading'. The patient usually presents with cyclical pain. The cysts have a propensity for multicentric growth and are often associated with fibrous adhesions. These latter features increase the MR sensitivity. Small peritoneal implants of endometriosis may be identified elsewhere and their conspicuity is increased by the use of fat saturation techniques.

Endometroid and clear cell carcinoma of the ovary are malignancies associated with endometriosis and these represent 17.5 and 7.4% of ovarian carcinomas, respectively. Chocolate cysts with multiple locules, mural foci, or nodules within the cyst are suspicious for malignancy and contrast should be administered if this appearance is seen.

The findings in this question are not consistent with a follicular cyst, which would show low T1WI and high T2WI signal.

Brenner tumours show low T2WI signal due to their abundant fibrous content and calcification, but also low T1WI signal. Fibrothecomas show intermediate T1WI signal and usually low (although sometimes it can be mixed high and low) T2WI signal. They sometimes show associated uterine enlargement, as they may be oestrogenic.

Izumi I, Wada A, Kaji Y, Hayashi T, Matsuo M et al. Developing an MR imaging strategy for diagnosis of ovarian masses. *Radiographics* 2006; 26: 1431-1448.



1. An HRCT chest is carried out on a 3-year-old girl. This child has a history of mild wheeze and tachypnoea, which has developed in the last few months. Standard treatment with bronchodilators and inhaled steroid for presumed asthma has been unsuccessful. The CXR is abnormal, showing mild increased airspace density. The HRCT shows a bilateral pattern of ground-glass change. The interlobular septa are markedly thickened, giving a 'crazy paving' pattern. What is the most likely diagnosis?

- A. *Pneumocystis jirovecii* pneumonia.
- B. Lymphocytic interstitial pneumonitis.
- C. Alveolar proteinosis.
- D. Childhood idiopathic pulmonary haemosiderosis.
- E. Childhood sarcoidosis.

2. A baby boy is born prematurely at 30 weeks gestation. Cranial ultrasound demonstrates bilateral multiseptate cystic lesions within the frontal lobe white matter with associated ex vacuo dilatation of the ventricles. Which of the following is the most likely diagnosis?

- A. Periventricular leucomalacia.
- B. Porencephaly.
- C. Supratentorial arachnoid cysts.
- D. Vein of Galen malformation.
- E. Subependymal cysts.

3. A 10-year-old girl presents with pain in the left hip which she first noticed when playing sports at school. Apart from pain on movement and several prominent café-au-lait spots, there is nothing else to find on examination. The patient is aphyrexia and her WCC and CRP are normal. A plain film of the pelvis reveals a lucent lesion in the proximal femoral metaphysis. The margins of the lesion are well defined and the metaphysis is expanded with adjacent cortical thinning. The lesion extends as far as, but does not involve, the physis. There is GGO in the centre of the lesion. There is no periosteal reaction. What is the most likely diagnosis?

- A. Osteomyelitis.
- B. Chondroblastoma.
- C. Aneurysmal bone cyst.
- D. GCT.
- E. Fibrous dysplasia.

4. A 2-day-old term neonate with an antenatal history of enlarged kidneys undergoes ultrasound of the renal tracts, which reveals bilateral enlarged and diffusely echogenic kidneys, with loss of cortico-medullary differentiation. Further assessment with a high-resolution linear probe reveals multiple small radially oriented cysts. Which of the following statements regarding this condition is false?
 - A. It is associated with congenital hepatic fibrosis.
 - B. The severities of renal and hepatic involvement are inversely proportional to each other.
 - C. Severe renal compromise is the immediate cause of death in the perinatal group.
 - D. Potter facies may be found in severely affected neonates.
 - E. It is associated with clubfoot deformity.
5. A 4-month-old infant presents with shortness of breath. A CXR is performed and this shows evidence of cardiac failure. The liver is noted to be enlarged and slightly irregular on examination. Ultrasound demonstrates multiple mixed echogenicity masses. A subsequent dynamic contrast-enhanced CT shows multiple lesions that show progressive centripetal enhancement. What is the most likely diagnosis?
 - A. Hepatoblastoma.
 - B. Multifocal hepatoma.
 - C. Mesenchymal hamartoma.
 - D. Metastases.
 - E. Infantile haemangiopericytoma.
6. You are attending a paediatric cardiac MRI list. The next patient is a 4-year-old girl who has undergone previous surgical correction of tetralogy of Fallot. Which of the following is the part of the report of most interest to the referring clinical team?
 - A. Pulmonary valve function.
 - B. Left ventricular function.
 - C. Presence of thrombus in the graft between IVC and pulmonary artery.
 - D. Stitus position.
 - E. Ventricular septum.
7. A 2-year-old girl is investigated for slow motor development via MRI. Which of the following radiological features would suggest a diagnosis of Dandy-Walker malformation, as opposed to Dandy-Walker variant?
 - A. Cerebellar dysgenesis.
 - B. Enlargement of the posterior fossa.
 - C. Agensis of the corpus callosum.
 - D. Holoprosencephaly.
 - E. Cystic dilatation of the fourth ventricle.

8. A 10-year-old boy presents with pain in his left leg following a minor fall whilst playing football. A plain film shows a mixed lytic/sclerotic lesion in the distal femoral metaphysis extending across the physis to involve the epiphysis. The lesion appears centred in the medulla and is causing cortical destruction. There is periosteal reaction and a Codman's triangle. No significant soft tissue component is visible. What advice do you give as a radiologist?

- Arrange urgent skeletal survey and CT brain.
- Advise treatment with antibiotics and arrange outpatient MRI.
- Arrange CT guided bone biopsy and MIBG scan.
- Arrange MRI, CT chest, and isotope bone scan.
- Perform CT chest, abdomen, and pelvis to look for a primary neoplasm elsewhere.

9. A 7-year-old girl presents with a history of continuous dribbling incontinence. On imaging she is found to have bilateral duplex kidney, complete ureteral duplication, and ectopic ureter. Which of the following statements regarding ectopic ureters and ureteral duplication is true?

- Ectopic insertion is more commonly associated with solitary ureter than complete ureteral duplication.
- Urinary incontinence with ectopic ureter is more common in boys.
- In complete ureteral duplication, the ureter of the upper pole moiety inserts into the bladder superior to the ureter of lower pole moiety.
- The upper moiety ureter is associated with ureterocele whereas the lower moiety ureter is associated with vesicoureteric reflux.
- The obstructed lower moiety may not be visualized on IVU.

10. A 14-year-old girl has an episode of pancreatitis. An MRCP examination is subsequently performed to assess for any biliary disease or pancreatic duct anomaly. You notice failure of fusion of the ventral and dorsal ducts, and suspect pancreas divisum. What other appropriate finding do you notice on the scan?

- Longer dorsal duct draining via major papilla/shorter ventral duct draining via minor papilla.
- Longer dorsal duct draining via minor papilla/shorter ventral duct draining via major papilla.
- Longer dorsal duct and shorter ventral duct both draining via the major papilla.
- Shorter dorsal duct draining via major papilla/longer ventral duct draining via minor papilla.
- Shorter dorsal duct draining via minor papilla/longer ventral duct draining via major papilla.
- Shorter dorsal duct and longer ventral duct both draining via the minor papilla.

11. A 4-month-old boy is having a barium swallow done in your department for suspected reflux. There is no relevant past medical history. On the AP view you notice a filling defect in the mid oesophagus. Your consultant recommends doing a lateral swallow to further assess this. This reveals a focal area of compression of the oesophagus anteriorly in the mid oesophagus. On the screening images you also notice a posterior impression on the trachea at this level. What is the most likely cause for this finding?
 - A. Duplication cyst.
 - B. Double aortic arch.
 - C. Lymphadenopathy.
 - D. Aberrant right subclavian artery.
 - E. Aberrant left pulmonary artery.
12. A 5-year-old boy is admitted for investigation of headache and vomiting. Unenhanced CT demonstrates a hyperdense mass centred on the cerebellar vermis and effacing the fourth ventricle. Homogenous enhancement is demonstrated on contrast administration. What is the most likely diagnosis?
 - A. Ependymoma.
 - B. Pilocytic astrocytoma.
 - C. Haemangioblastoma.
 - D. Brainstem glioma.
 - E. Medulloblastoma.
13. A 2-month-old boy is brought to A&E by his mother with a swollen, tender ankle which she had noticed that afternoon. She does not recall any injury and the child is otherwise well. You are in A&E out of hours for an unrelated matter when the A&E doctor shows you the plain film, which reveals a metaphyseal fracture of the distal tibia. What is the next appropriate radiological step?
 - A. To arrange a follow-up film 2 weeks after treatment.
 - B. To arrange an urgent 'babygram' (single plain film of the child).
 - C. To arrange a CT brain that night, followed by a skeletal survey the following morning.
 - D. To arrange an urgent out-of-hours skeletal survey.
 - E. To arrange an urgent isotope bone scan.
14. A 15-year-old female undergoes a pelvic MRI on which incidental note is made of a 1.5-cm lesion antero-lateral to the vagina and above the level of the inferior margin of the pubic symphysis. The lesion is hypointense on T1WI and hyperintense on T2WI. There is no displacement of or communication with the urethra. What is the likely diagnosis?
 - A. Urethral diverticulum.
 - B. Gartner duct cyst.
 - C. Bartholin gland cyst.
 - D. Skene duct cyst.
 - E. Urethral caruncle.

15. A 6-week-old neonate presents with several episodes of bilious vomiting. You suspect the child may have a malrotation. Which of the following findings on imaging is the most specific for midgut volvulus having occurred?

- A. Reversal of the normal orientation of the superior mesenteric artery and vein on ultrasound.
- B. High medial position of the caecum on a contrast enema.
- C. Positioning of the duodenal-jejunal flexure to the right of midline on an upper GI contrast study.
- D. Duodenal-jejunal corkscrew appearance on an upper GI contrast study.
- E. Duodenal obstruction on an upper GI contrast study.

16. You are reviewing the daily radiograph on a 4-week-old neonate in the neonatal ICU. This patient was born at 32 weeks and was diagnosed with uncorrected transposition of the great arteries with an intact ventricular septum for which he underwent an emergency balloon atrial septostomy for palliation, whilst awaiting an arterial switch operation (ASO). As part of your routine practice, you review the position of the lines. The ET tube is located 9 mm from the carina. The right internal jugular vein central line is sited in the mediastinum, 8 mm inferior to the carina. The umbilical venous catheter (UVC) passes superiorly from the umbilicus, with its tip at the inferior aspect of the right atrium. The umbilical arterial line (UAC) passes inferiorly before passing superiorly, with its tip located at the level of T9. The nasogastric tube tip is below the diaphragm. Which of these pieces of apparatus may be incorrectly sited?

- A. ET tube.
- B. Nasogastric tube.
- C. UAC.
- D. Central line.
- E. UVC.

17. A 14-month-old girl is brought to A&E with a head injury following a fall at home. Clinical examination reveals that the child is unkempt and has multiple bruising. Which of the following potential findings on CT raises the greatest suspicion for non-accidental injury (NAI)?

- A. Parietal skull fracture.
- B. Temporal lobe extradural haematoma.
- C. Inter-hemispheric subdural haematoma.
- D. Bilateral frontal enlargement of the subarachnoid space.
- E. Soft-tissue swelling overlying the occiput.

18. A child is diagnosed with neuroblastoma. He is referred for staging and you are asked to advise on the standard radiological investigation of bony metastases. What do you advise?
- Whole body MRI.
 - Whole body $^{18}\text{-FDG}$ PET-CT.
 - $^{123}\text{-I}$ -metaiodobenzylguanidine (MIBG) scan.
 - $^{99\text{m}}\text{Tc}$ methylene-diphosphonate (MDP) isotope bone scan.
 - MIBG and isotope bone scan.
19. A 15-year-old boy is homozygous for the delta F508 mutation for CF. He has poor weight gain and is diagnosed as having pancreatic insufficiency. What is the most likely imaging finding in his pancreas?
- Diffuse pancreatic swelling.
 - Diffuse fatty infiltration and fibrosis.
 - Diffuse scattered microcysts (less than a few millimetres in size) within the pancreas.
 - Complete replacement of the pancreas with macrocysts.
 - Diffuse pancreatic calcification.
20. A cardiac MRI is being carried out on an infant for a conotruncal rotational abnormality. It is clear that this infant has 150 clockwise rotation of the great vessels. What conotruncal rotation abnormality does this infant have?
- Normal rotation.
 - Situs inversus.
 - L-transposition.
 - D-transposition.
 - Double-outlet right ventricle.
21. A 12-year-old boy is investigated via MRI brain for headache, nystagmus, and ataxia. Which of the following radiological findings would suggest a diagnosis of Chiari I malformation as opposed to Chiari II?
- Lacunar skull.
 - Myelomeningocele.
 - Elongation of the fourth ventricle.
 - Caudal displacement of the cerebellar tonsils.
 - Cervicomedullary kinking.
22. A 12-year-old who is a keen athlete presents with left groin pain. A plain film of the pelvis reveals avulsion of the apophysis of the left ischial tuberosity. Which muscle attachment has he injured?
- Sartorius.
 - Hamstrings.
 - Adductors.
 - Rectus femoris.
 - Iliopsoas.

23. An infant with ambiguous genitalia is referred for ultrasound of pelvis. This shows a normal uterus and ovaries, suggesting female pseudohermaphroditism. There is elevated 17-hydroxy-progesterone. What further investigation is recommended?

- A. Ultrasound of adrenal glands.
- B. MRI of pelvis.
- C. Fluoroscopic genitography.
- D. Laparoscopy.
- E. Ultrasound of inguinal region.

24. A 6-day-old neonate presents with persistent vomiting. A plain x-ray of abdomen shows a dilated stomach and proximal duodenum, suggesting a high-grade duodenal obstruction. A subsequent upper GI contrast study confirms obstruction in the second part of the duodenum with a 'windsock' type deformity evident. What is the most likely diagnosis?

- A. Duodenal atresia.
- B. Midgut volvulus.
- C. Annular pancreas.
- D. Predodenal portal vein.
- E. Duodenal web.

25. A male neonate born at 38 weeks gestation develops acute respiratory distress within 36 hours of delivery. Clinical examination reveals coarse breath sounds. Serial CXRs carried out in the Special Care Baby Unit (SCBU) reveal reduced lung volumes and widespread granular opacities. There is reduced transradiancy in the right hemithorax and an ultrasound reveals that this is secondary to a mild-moderate pleural effusion. What is the most likely diagnosis?

- A. Surfactant deficiency.
- B. Meconium aspiration.
- C. Bronchopulmonary dysplasia (BPD).
- D. Beta haemolytic streptococcal pneumonia.
- E. Pulmonary interstitial emphysema (PIE).

26. A 4-year-old boy is investigated via MRI brain for developmental delay and intractable seizures. Which of the following findings is in keeping with a diagnosis of schizencephaly?

- A. Intracerebral cleft lined by gray matter connecting the lateral ventricle to the subarachnoid space.
- B. Smooth cortical surface with absence of convolutions.
- C. Multiple small, irregular cortical convolutions without intervening sulci.
- D. Column of gray matter extending from the subependymal to the pial surface.
- E. Circumferential, symmetric band of heterotopic gray matter deep to the cortical surface.

27. A 6-year-old child attends A&E with neck pain and tenderness after landing badly whilst trampolining in a neighbour's back garden. Which of the following findings is most concerning?

- A. C2/3 subluxation.
- B. Overhang of the lateral masses of C1 on C2 of 6 mm.
- C. An atlanto-dens interval (ADI) of 6 mm.
- D. Prevertebral soft tissue of 6 mm at C3.
- E. Anterior wedging of C3.

28. A 6-week-old infant presents with a history of failure to thrive. Plain abdominal radiograph demonstrates punctate calcification in the region of the adrenal glands. Which of the following findings on CT of abdomen is most specific for Wolman disease?

- A. Hepatosplenomegaly.
- B. Enlarged retroperitoneal lymph nodes.
- C. Diffuse fatty infiltration of the liver.
- D. Enlarged calcified adrenals that maintain their normal triangular configuration.
- E. Thickening of small bowel.

29. A 4-week-old neonate presents with persistent jaundice. The hyperbilirubinaemia is conjugated. An ultrasound scan of liver and gallbladder does not reveal a significant abnormality. A subsequent Hepatobiliary Iminodiacetic Acid (HIDA) scan shows decreased parenchymal extraction and clearance of radioisotope from the bloodstream, but tracer does eventually reach the gut. What is the jaundice is most likely to be due to?

- A. Biliary atresia.
- B. Caroli's disease.
- C. Neonatal hepatitis.
- D. Physiological jaundice of the newborn.
- E. Hypothyroidism.

30. A male neonate born at 26 weeks gestation is currently being treated in your neonatal ICU. The patient's mother received corticosteroids prior to delivery and prophylactic surfactant administration as per your department's standard practice. The CXR was clear for the first 7 days. Despite this the child developed streaky perihilar granular opacities and respiratory difficulties. Further surfactant administration has been carried out, but the CXR carried out today (day 28 postpartum) shows small streaky linear densities along with cystic bubbly lucencies, which have been becoming increasingly prominent over the last 7 days and are distributed in an irregular pattern bilaterally. What is the most likely explanation for this appearance?

- A. Surfactant deficiency.
- B. Meconium aspiration.
- C. BPD.
- D. Beta haemolytic streptococcal pneumonia.
- E. PIE.

31. A 14-year-old boy is having a follow-up MRI brain for a known seizure disorder. Axial T2WI demonstrates gyriiform low signal in the left occipital and temporal lobes with corresponding volume loss. Leptomeningeal enhancement is present on the axial T1WI post contrast. A right-sided developmental venous anomaly (DVA) is also present. What is the most likely diagnosis?

- A. Neurofibromatosis type 1.
- B. Neurofibromatosis type 2.
- C. Sturge Weber syndrome.
- D. Tubercous sclerosis.
- E. Von Hippel-Lindau disease.

32. A child presents after trauma to the elbow. Which configuration of the following ossification centres is most suspicious for significant injury?

- A. Capitellum present before radial head.
- B. Radial head present before trochlea.
- C. Trochlea present before internal epicondyle.
- D. Internal epicondyle present before olecranon.
- E. Olecranon present before external epicondyle.

33. A 5-year-old girl with a history of precocious puberty and increased serum inhibin levels is referred for ultrasound of the pelvis. On ultrasound, there is a complex solid/cystic mass in the adnexa. MRI of the pelvis confirms a solid/cystic ovarian mass with a 'sponge-like appearance' on T2WI. What is the likely diagnosis?

- A. Sertoli-Leydi cell tumour.
- B. Juvenile granulosa cell tumour.
- C. Mature cystic teratoma.
- D. Fibroma.
- E. Mucinous cystadenocarcinoma.

34. A 4-month-old child presents with abdominal distension and signs of obstruction. A plain film of abdomen shows mild small bowel distension with some displacement of loops in the lower abdomen and pelvis by a homogeneous density. A subsequent ultrasound of the abdomen and pelvis shows a 7-cm cystic lesion in the lower abdomen. It is anechoic, but has a definable wall that has an inner echogenic line and an outer hypoechoic layer. What is the most likely diagnosis?

- A. Mesenteric cyst.
- B. Omental cyst.
- C. Ovarian cyst.
- D. Lymphangioma.
- E. Duplication cyst.

- 35.** A 3-month-old child presents to the paediatric outpatient clinic with a history of recurrent respiratory distress. The child had an uneventful delivery, but has had recurrent problems since birth. The child had a CXR taken prior to discharge home, aged 2 days, which showed a density in the left upper lobe, felt by the paediatrician to represent the thymus. Whilst the infant has never required admission, the mother is concerned due to recurrent coughing and dyspnoea. A CXR obtained at the clinic shows a large hyperlucent area in the left upper lobe. What is the most likely diagnosis?
- A. Congenital lobar emphysema.
 - B. Congenital cystic adenomatoid malformation.
 - C. Pulmonary sequestration.
 - D. Persistent PLE.
 - E. Congenital diaphragmatic hernia.
- 36.** A 12-year-old boy presents with a painless neck mass which recently increased in size after an upper respiratory tract infection. Which of the following radiological findings are in keeping with a second branchial cleft cyst?
- A. Anechoic cystic mass posterior to sternocleidomastoid in the posterior triangle.
 - B. Lateral echogenic mass with hypoechoic vascular channels.
 - C. Anechoic cystic mass anterior to sternocleidomastoid near the angle of the mandible.
 - D. Anechoic cystic mass in an infrahyoid midline location.
 - E. Anechoic cystic mass inferior and posterior to the tragus.
- 37.** A 12-year-old boy injures his ankle whilst playing football. The plain film reveals a lucent line through the distal metaphysis of the tibia and touching, but not crossing, the physis into the epiphysis. This represents a:
- A. Salter-Harris type 1 injury.
 - B. Salter-Harris type 2 injury.
 - C. Salter-Harris type 3 injury.
 - D. Salter-Harris type 4 injury.
 - E. Normal variant.
- 38.** An antenatal ultrasound of foetus at 20 weeks gestation reveals an occipital encephalocele. Foetal MRI demonstrates bilateral enlarged kidneys with cystic dysplasia and polydactyly. What is the diagnosis?
- A. Autosomal recessive polycystic kidney disease.
 - B. Bardet-Biedl syndrome.
 - C. Meckel-Gruber syndrome.
 - D. Tuberosus sclerosis.
 - E. Zellweger syndrome.

39. A 7-day-old neonate presents with delayed passage of meconium and abdominal distension. There is no vomiting. An AXR shows non-specific gas-filled loops of bowel extending distally with air/fluid levels. A water-soluble contrast enema is performed and this shows a large filling defect in the proximal descending colon. There is a calibre change at this site between a small distal colon and mildly distended proximal colon. The colon wall is otherwise smooth, with no abnormal contractions or wall irregularity. What is the most likely diagnosis?

- A. Hirschsprung's disease.
- B. Meconium plug syndrome.
- C. Meconium ileus syndrome.
- D. Small left colon syndrome.
- E. Colonic atresia.

40. One of the obstetricians in your hospital refers a pregnant patient, who is at 34 weeks gestation, to your department for assessment, as an antenatal ultrasound has shown a mass in the chest of the foetus. A repeat ultrasound confirms a hyperechoic mass confined to the inferior aspect of the left hemithorax. This mass is vascular. Incidental note is also made of a ventricular septal defect. An MRI confirms the presence of a high-signal intrathoracic mass in the left lower thorax, which derives its blood supply from the abdominal aorta. The lung surrounding this area appears unremarkable. What is the most likely diagnosis?

- A. Congenital diaphragmatic hernia.
- B. Intralobar sequestration.
- C. Congenital cystic adenomatoid malformation.
- D. Foregut duplication cyst.
- E. Extralobar sequestration.

41. An 18-month-old girl presents with increasing incoordination and developmental regression. T2WI demonstrates confluent high signal within the periventricular white matter and centrum semiovale, with radiating linear low signal intensity, giving a 'tigroid' pattern. Sparing of subcortical U fibres is also noted. What is the most likely diagnosis?

- A. Krabbe disease.
- B. Metachromatic leucodystrophy.
- C. X-linked adrenoleucodystrophy.
- D. Alexander disease.
- E. Canavan disease.

- 42. A 10-year-old boy presents with left hip pain. Which of the following radiographic features makes the diagnosis of Perthes' disease more likely than slipped upper femoral epiphysis (SUFE)?**
- Failure of intersection of the superior femoral epiphysis by the line of Klein.
 - Widening of the physis.
 - Irregularity of the physis.
 - Sclerosis in the regional femoral neck.
 - Widening of the joint space.
- 43. A 10-year-old girl presents with right hip pain. Which of the following radiographic features makes the diagnosis of SUFE more likely than Perthes' disease?**
- Reduction in size of the proximal femoral epiphysis.
 - Loss of overlap between the medial femoral metaphysis and acetabulum.
 - Regional femoral demineralization.
 - A crescent of subcortical lucency in the femoral head.
 - Fragmentation of the femoral head.
- 44. A full-term infant with unilateral cryptorchidism is referred for ultrasound assessment. Which is the most common location of a cryptorchid testis?**
- Inguinal canal.
 - Superficial inguinal ring.
 - Deep inguinal ring.
 - Femoral triangle.
 - Abdomen.
- 45. An 8-month-old child presents with gradually increasing abdominal swelling. An ultrasound scan of abdomen is performed and this shows a large liver mass, which is well-defined and slightly hyperechoic to surrounding hepatic parenchyma. A subsequent biphasic CT scan confirms a solitary heterogeneous, but predominantly hypodense, liver mass on both phases with some calcification. The serum alphafetoprotein is elevated. What is the most likely diagnosis?**
- Hepatic angiosarcoma.
 - Mesenchymal hamartoma.
 - Undifferentiated embryonal sarcoma.
 - Hepatoblastoma.
 - Hepatocellular carcinoma.

46. A 6-year-old presents to A&E with a history of a productive cough associated with green sputum and mild wheeze. This child had a similar event 2 years earlier. Clinical examination reveals mild tachypnoea and coarse breath sounds. A CXR is requested. Your consultant points out the salient findings on the CXR as being the presence of hyperinflation, possible areas of air trapping, peribronchial wall oedema bilaterally, subsegmental atelectasis in the right midzone, and slight perihilar haziness. Your consultant asks you what you would do with this child given the findings. What do you say?

- A. Send them home and reassure the parents.
- B. Repeat CXR in 4 weeks to look for resolution.
- C. Start antibiotics and reassess in 2 weeks.
- D. Do expiratory films to rule out inhaled foreign body.
- E. Respiratory consult and HRCT chest due to air-trapping.

47. A premature baby girl is noted to have a skull deformity consistent with scaphocephaly. Fusion of which vault suture or sutures gives rise to this craniosynostosis?

- A. Coronal suture.
- B. Sagittal suture.
- C. Lambdoid suture.
- D. Metopic suture.
- E. Sagittal, coronal, and lambdoid sutures.

48. A 12-year-old male presents with a history of sudden onset of severe pain in the right testis. On examination, the right testis is tender and higher in position compared to the left side. An ultrasound of testes is requested. Which of the following statements regarding testicular torsion is true?

- A. Torsion results in arterial obstruction first followed by venous obstruction.
- B. The testis is usually salvageable if corrected within 24 hours.
- C. Bell clapper deformity predisposes to testicular torsion.
- D. Enlargement and heterogeneous echogenicity of the testis is specific for torsion.
- E. Clinical differentiation between testicular torsion and epididymo-orchitis is straightforward.

49. A 6-week-old male child presents with non-bilious vomiting after feeds, which has more recently become projectile in nature. You clinically suspect hypertrophic pyloric stenosis. Which of the following ultrasound findings would be inconsistent with this diagnosis?

- A. Pyloric muscle thickness of 4 mm.
- B. The presence of retrograde gastric contractions.
- C. Pyloric thickness (serosa to serosa) of 10 mm.
- D. The presence of hyperperistaltic gastric contractions.
- E. Pyloric channel length of 12 mm.

50. A CT chest has been requested for a neonate in the neonatal ICU. This infant was born at 27 weeks gestation and developed right-sided PLE during the first week of life. The neonatologists practiced selective left bronchial intubation and no further air leak sequelae occurred. Also present on the CXR is a hyperlucent lesion in the right lower lobe. This is not clearly seen on the initial radiographs due to the generalized haziness present due to the surfactant deficiency. This lesion is not increasing in size and is not causing any significant respiratory embarrassment, but requires further assessment to define treatment. On CT a focal lesion is present confined to the right lower lobe, which consists of multiple cystic structures with central linear densities. This area demonstrates mild expansion. What is the diagnosis?
- Congenital cystic adenomatoid malformation.
 - Persistent PLE.
 - Congenital diaphragmatic hernia.
 - Congenital lobar emphysema.
 - Bronchogenic cyst.
51. A 10-year-old boy of Japanese origin presents with episodes of right transient hemiparesis and declining intellect. MRI brain is performed. Which of the following are the most likely radiological findings?
- Multiple flow voids within the basal ganglia bilaterally.
 - Irregular beading of the left extracranial internal carotid artery.
 - Hypoplasia of the left internal carotid artery.
 - Distal left middle cerebral artery aneurysm.
 - Normal study.
52. A 13-year-old boy presents with activity-related knee pain and locking. A plain film is unremarkable. An MRI reveals a defect in the lateral aspect of the medial femoral condyle. There is increased signal in the adjacent bone marrow on T2WI. What is the most likely diagnosis?
- Distal femoral cortical irregularity.
 - Osteochondritis dissecans.
 - Sinding-Larsen-Johansson disease.
 - Osgood-Schlatter disease.
 - Avulsion of the anterior tibial spine.
53. A 5-year-old girl presents with a pelvic mass with extension into the gluteal region through the sciatic foramen. Which of the following statements regarding sciatic foramenal anatomy is correct?
- Piriformis muscle forms the boundary between the greater and lesser sciatic foramen.
 - The sacrotuberous ligament divides the greater sciatic foramen into superior and inferior compartments.
 - The pudendal nerve and internal pudendal vessels pass through the lesser sciatic foramen.
 - The sciatic nerve passes through the superior part of greater sciatic foramen.
 - The superior gluteal vessels and nerve pass through the inferior part of the greater sciatic foramen.

54. A pregnant mother is having an antenatal foetal anomaly scan and the ultrasonographer asks for your opinion on a large hernia arising from the anterior abdominal wall of the foetus, to try and determine between an omphalocele and a gastroschisis. Which of the following findings makes an omphalocele more likely than a gastroschisis?

- A. The lack of a peritoneal covering.
- B. The presence of the stomach in the herniated defect.
- C. The umbilical cord inserting at the apex of the hernia.
- D. The site of the hernia slightly lateral to the midline.
- E. The lack of any other associated congenital anomalies.

55. A 4-day-old cyanosed infant is admitted as an emergency to SCBU following a home birth. The history is of episodes of severe cyanosis developing when the infant is distressed. A CXR is carried out and shows a normal mediastinal contour with slightly decreased pulmonary vascularity. What do you think the most likely cause of this infant's cyanosis is based on these findings?

- A. Truncus arteriosus.
- B. Pulmonary valve atresia with an intact ventricular septum.
- C. Pulmonary valve hypoplasia with a VSD and overriding aorta.
- D. D-transposition of the great arteries.
- E. Coarctation of the aorta.

56. An 18-month-old boy is referred for CT after presenting with a right-sided white eye reflex (leucocoria). Which radiological feature is most in keeping with a diagnosis of retinoblastoma, as opposed to non-neoplastic causes of leucocoria (pseudoretinoblastoma)?

- A. Contrast enhancement.
- B. Calcification.
- C. Microphthalmia.
- D. Mass extension into the vitreous.
- E. Secondary retinal detachment.

57. An 11-year-old boy falls and injures his elbow. Which of the following combination of injuries is most likely?

- A. Posterior dislocation and capitellum fracture.
- B. Anterior dislocation and lateral epicondyle fracture.
- C. Posterior dislocation and medial epicondyle fracture.
- D. Anterior dislocation and trochlea fracture.
- E. Posterior dislocation and radial head fracture.

58. A 6-year-old boy undergoes an ultrasound examination of the renal tracts that shows dilated, polygonal, multifaceted calyces in the right kidney. The fundibula, renal pelvis, and ureter are normal in calibre. IVU confirms the ultrasound findings and there is normal contrast excretion. What is the diagnosis?
- Congenital megacalyces.
 - Obstructive hydronephrosis.
 - Multicystic dysplastic kidney.
 - Congenital megacystis-microcolon syndrome.
 - Vesico-ureteric reflux.
59. A 10-year-old boy presents with a 1-day history of severe epigastric pain radiating to the back. Serum amylase is elevated. The patient has an ultrasound scan of abdomen performed which does not show evidence of gallbladder or biliary disease. Pancreatitis is suspected. What is the most useful sign with regard to the pancreas on ultrasound that would support this diagnosis?
- Increased pancreatic echogenicity.
 - Decreased pancreatic echogenicity.
 - Pancreatic duct dilatation.
 - Pancreatic atrophy.
 - Pancreatic calcification.
60. A male neonate is born at 40 weeks gestation. There is a history of polyhydramnios during pregnancy. During baby checks, the baby is noted to have a sacral dimple. At this time the mother reports that the baby has been unable to feed properly during the initial 24 hours, during which it dribbles and spits out milk. She also reports the baby has had recurrent coughing episodes. The paediatrician is unable to pass an nasogastric tube and suspects a tracheoesophageal fistula. A contrast swallow is requested. This demonstrates termination of the proximal oesophagus, with a fistulous connection between the proximal oesophagus and the trachea. Contrast does not pass into the distal oesophagus. What class of tracheoesophageal fistula is this likely to be?
- Type A.
 - Type B.
 - Type C.
 - Type D.
 - Type E.

61. An 8-year-old boy presents with a painful scalp swelling over the right frontal region for the last 6 weeks. An initial skull radiograph demonstrates a punched out oval osteolytic lesion with an apparent double contour or bevelled edge. The lesion does not have a sclerotic margin and no periosteal reaction is seen. Which of the following is the most likely diagnosis?
- Epidermoid cyst.
 - Neuroblastoma metastasis.
 - Langerhans cell histiocytosis (LCH).
 - Haemangioma.
 - Osteoma.
62. A 12-year-old boy undergoes a plain film of his left knee after minor trauma playing rugby. The film reveals a lucent, cortically based lesion with a sclerotic rim in the metaphysis of the proximal tibia. There is no periosteal reaction or soft-tissue component and the boy denies pain prior to the injury. As the reporting radiologist you advise:
- plain films of the extremities to look for similar lesions
 - MRI of the left lower leg and CT chest
 - isotope bone scan
 - CT of left lower leg
 - none of the above.
63. A 15-year-old male undergoes a pelvic MRI on which an incidental note is made of absent bilateral seminal vesicles. Which of the following is commonly associated with bilateral seminal vesicle agenesis?
- Renal agenesis.
 - CF.
 - Calcified vas deferens.
 - Ectopic ureter.
 - Rotation anomaly of one kidney.
64. A neonate is born at 34 weeks gestation. During the first week of life it presents with bloody diarrhoea and abdominal distension. You wonder about the possibility of necrotising enterocolitis. Which one of the following radiological investigations is unlikely to be helpful in the acute setting?
- Supine AXR.
 - Left lateral decubitus AXR.
 - Water-soluble contrast enema.
 - Ultrasound of abdomen.
 - Supine cross-table lateral AXR.

65. A 7-year-old boy is being investigated for a history of mild exertional dyspnoea. A CXR has been carried out that shows normal lungs but does demonstrate a linear density passing inferiorly from the right lower hemithorax to the level of the diaphragm. A cardiac MRI has been requested, which shows normal pulmonary venous drainage on the left side. On the right side, the lower pulmonary vein drains into the right atrium, the superior pulmonary vein drains into the left atrium, and the arterial supply for the entire right lung arises from the pulmonary artery. No cardiac abnormality is identified. What form of abnormality does this child have?
- Total anomalous pulmonary venous return.
 - Partial anomalous pulmonary venous return (PAPVR).
 - Extralobar sequestration.
 - Cor triatriatum.
 - Scimitar syndrome.
66. A 14-year-old boy presents with a slow-growing painless mass at the angle of the mandible on the left. Ultrasound demonstrates a hypoechoic left parotid mass containing echogenic calcific foci. On follow-up contrast-enhanced MRI, the mass demonstrates mild increased enhancement. Which of the following is the most likely diagnosis?
- Warthin tumour.
 - Primary lymphoma.
 - Parotitis.
 - Pleomorphic adenoma.
 - Haemangioma.
67. A 5-year-old boy with bilateral wrist pain undergoes a plain film which reveals several pedunculated bony outgrowths from the metaphyses of both radii, which point away from the adjacent joints. What is the most likely diagnosis?
- Ollier disease.
 - Maffucci syndrome.
 - Morquio syndrome.
 - Diaphyseal aclasia.
 - Hunter syndrome.
68. A 15-year-old female undergoes an ultrasound of pelvis that demonstrates uterine abnormality with a differential diagnosis of bicornuate or septate uterus. An MRI of the pelvis is requested for further assessment. Which of the following findings on MRI is suggestive of a bicornuate uterus?
- Two uterine cavities.
 - Fundal concavity of less than 1 cm.
 - Intercornual distance of more than 4 cm.
 - Convex external fundal contour.
 - Thin fibrous low-intensity septum separating the uterine cavities.

69. A 2-year-old boy presents with abdominal pain and clinical signs of GI bleeding. The clinical team wish to exclude a Meckel's diverticulum and request a radionuclide 'Meckel's scan'. What ectopic tissue is required in the Meckel's diverticulum for the scan to be successful?

- A. Colonic tissue.
- B. Gastric mucosa.
- C. Exocrine pancreatic tissue.
- D. Pancreatic islet cells.
- E. Thyroid tissue.

70. A 6-year-old girl is brought to your local paediatric outpatients with a history of night sweats, tiredness, and new onset wheeze not responding to bronchodilators. A CXR is done which shows increased mediastinal soft tissue noted superiorly. The paravertebral lines are maintained. The aortic knuckle is not visible. A lateral CXR has been carried out at the request of the paediatrician, which shows increased soft tissue displacing the trachea posteriorly, causing mild narrowing. What is the most likely diagnosis?

- A. Tuberculosis.
- B. Lymphangioma.
- C. Bronchogenic cyst.
- D. Thymic/nodal malignant infiltration.
- E. Teratoma.

71. Follow-up MRI is performed on a foetus of 26 weeks gestational age after ultrasound raised the suspicion of agenesis of the corpus callosum (ACC). This subsequently confirms that the callosum is absent. What is the most likely additional radiological finding?

- A. None, isolated abnormally.
- B. Parenchymal T2WI signal hypointensity.
- C. Periventricular nodular heterotopia.
- D. Dysplastic brainstem.
- E. Delayed sulcation.

72. An infant is of short stature and undergoes a skeletal survey. This reveals markedly shortened femora and humeri, although the other long bones are also greatly affected. The vertebral bodies are moderately flattened and there is a reduction in the interpedicular distance in a caudal direction in the spine. What is the diagnosis?

- A. Thanatophoric dysplasia.
- B. Achondroplasia.
- C. Chondrodysplasia punctata.
- D. Jeune syndrome.
- E. Cleidocranial dysplasia.

73. A 14-year-old girl presents with sudden onset of severe right-sided lower abdominal pain, nausea, and vomiting. An ultrasound of the pelvis is requested with a suspected diagnosis of ovarian torsion. Which of the following is the most constant ultrasound finding in ovarian torsion?

- A. Enlarged ovary.
- B. Absent ovarian blood flow.
- C. Pelvic free fluid.
- D. Twisted ovarian pedicle.
- E. 'String of pearls' sign.

74. A 15-year-old boy presents with severe abdominal pain. He has a known history of a 'polypoid' syndrome. A plain AXR shows small bowel obstruction. A subsequent CT scan of abdomen indicates that this is due to a small bowel intussusception. Which 'polypoid' syndrome does he most probably have?

- A. Cronkhite-Canada syndrome.
- B. Familial adenomatous polyposis syndrome.
- C. Cowden disease.
- D. Gardner's syndrome.
- E. Peutz-Jegher's syndrome.

75. With appropriate clinical suspicion, which of the following radiologically depicted injuries would most raise suspicion of NAI?

- A. Posterior rib fracture.
- B. Vertebral compression fracture.
- C. Duodenal haematoma.
- D. Spiral fracture of long bone.
- E. Jejunal laceration.

1. C. Alveolar proteinosis.

Interstitial lung disease in children is uncommon, but it is important to be aware of as 50% of children present with a history of wheeze. Chronic idiopathic pulmonary haemosiderosis does not cause a 'crazy paving' pattern. It is a rare disorder (although common in exams) and when present in children usually presents before 3 years of age. Whilst a 'crazy paving' pattern was originally described as being typical of alveolar proteinosis, it has since been described in numerous conditions and as such a knowledge of these processes is necessary to differentiate them. *Pneumocystis jirovecii* pneumonia would not normally be considered in the absence of a history of immunocompromise. Whilst NSIP can cause this appearance, in children it more typically has an upper zone and peripheral predominance with associated ground-glass changes and a degree of honeycombing. The imaging characteristics of NSIP, LIP and DIP overlap in children and often require lung biopsy to differentiate them. LIP is also usually associated with immunodeficiency disorders, as in adults. Sarcoidosis in children is very rare and usually presents in older children, around 13–15 years of age.

Koh D and Hansell D. Computed tomography of diffuse interstitial lung disease in children. *Clinical Radiology* 2000; 55(9): 659–667.

2. A. Periventricular leucomacia.

This refers to white matter necrosis, typically involving the centrum semiovale, and is seen in premature infants. This results from hypoxic-ischaemic injury at the watershed areas, which in premature infants are present in a periventricular location. Periventricularly refers to an area of encephalomalacia, which may or may not communicate with the ventricular system and develops postnatally or in the third trimester. This is the end result of a destructive process, such as an intraparenchymal haemorrhage. Sylvian fissure cysts are the most common site for supratentorial arachnoid cysts. Vein of Galen malformations occur in the midline and exhibit Doppler flow. Subependymal cysts are detected in the caudothalamic groove.

Epelman M, Daneman A, Blaser SI, Ortiz-Neira C, Konen O, Jarvin J et al. Differential diagnosis of intracranial cystic lesions at head US: correlation with CT and MR imaging. *Radiographics* 2006; 26: 173–196.

3. E. Fibrous dysplasia.

The clue here is the café-au-lait spots, which are seen in McCune–Albright syndrome (unilateral polyostotic fibrous dysplasia, precocious puberty, and café-au-lait spots). Osteomyelitis is unlikely because of the normal inflammatory markers, lack of systemic symptoms, and lack of periosteal reaction. Aneurysmal bone cyst and GCTs are possibilities (the former may even complicate fibrous dysplasia). Chondroblastoma is an epiphyseal lesion.

Manaster BJ, May DA, and Disler DG. *Musculoskeletal Imaging: The Requisites*. 3rd edn, Mosby, 2007, pp. 460–465.

4. C. Severe renal compromise is the immediate cause of death in the perinatal group.

The incidence of autosomal recessive polycystic kidney disease (ARPKD) is approximately 1:20,000 births. It is a disease of tubular ectasia and fibrosis that results in bilateral enlarged kidneys, with loss of cortico-medullary differentiation and multiple small radially arranged cysts. ARPKD is associated with congenital hepatic fibrosis, the severity of which is inversely proportional to the renal abnormality.

Four distinct groups of ARPKD are recognized based on age at presentation: perinatal, neonatal, infantile, and juvenile. The most severe renal involvement is seen in the perinatal group. In this group, severe renal impairment results in reduced urine output, oligohydramnios, and pulmonary hypoplasia. Severe respiratory compromise is the immediate cause of death in these patients. Oligohydramnios is also associated with Potter facies (low set and flattened ears, short and snubbed nose, deep eye creases, and micrognathia) and clubfoot deformity.

Loneragan GJ, Rice RR, and Suarez ES. Autosomal recessive polycystic kidney disease: radiologic-pathologic correlation. *Radiographics* 2000; 20: 837–855.

5. E. Infantile haemangioblastoma.

Also known as infantile hepatic haemangioblastoma, infantile haemangioblastoma is a vascular neoplasm and the most common benign hepatic tumor of infancy. It may be a solitary mass or multifocal, and most are diagnosed before the age of 1 year. The lesion itself runs a benign course, but life-threatening clinical complications may occur. These include high-output cardiac failure secondary to large arterio-venous shunts and Kasabach–Merritt syndrome of coagulopathy secondary to intratumoral platelet sequestration. On ultrasound the lesions are well-demarcated and are generally hypoechoic or of mixed echogenicity. On CT and MRI the enhancement pattern of the lesion is similar to adult haemangioma. There is intense early peripheral nodular enhancement, with centripetal progression on the later images.

Hepatoblastoma rarely occurs in the newborn but can be seen in young infants. This tumour is distinguished by a heterogeneous rather than intense centripetal enhancement pattern and markedly elevated levels of alpha-fetoprotein (AFP) in 90% of patients. AFP level is rarely elevated in infantile haemangioblastoma.

Mesenchymal hamartoma of the liver, like infantile haemangioblastoma, may also be found in the perinatal period. This benign tumour differs in imaging appearance from infantile haemangioblastoma in that it usually appears as a multicystic, multilocular mass with enhancement of only the septa and solid portions. Less commonly, mesenchymal hamartoma may be predominantly solid, but it differs from infantile haemangioblastoma in that it is hypovascular at dynamic contrast-enhanced imaging.

Whilst metastases could occur in an infant (e.g. neuroblastoma), they would tend to be hypodense to normal liver on contrast-enhanced CT. Hepatoma is exceedingly rare in an infant and the imaging characteristics described would not be typical.

Chung EM, Cude R, Lewis RB, and Conran RM. Pediatric liver masses: radiologic-pathologic correlation Part 1. Benign tumors. *Radiographics* 2010; 30: 801–826.

6. A. Pulmonary valve function.

As a general rule, pre-operative imaging of paediatric cardiac malformations focuses on the morphology, to allow accurate characterization of the abnormality pre-operatively. Post-operative imaging focuses more on function, to assess the success of the treatment given and need for further intervention. With regard to a corrected tetralogy of Fallot, the situs will be known and the ventricular septum assessed and usually repaired at surgery. A graft between the systemic venous system and pulmonary artery is a feature of a Fontan/Glenn procedure and these are most commonly carried out for tricuspid atresia, not tetralogy of Fallot. Assessment of the

pulmonary valve, along with right ventricular function, is essential in this post-operative patient, as re-stenosis of the pulmonary valve or progressive right ventricular impairment are associated with increased morbidity.

Krishnamurthy R. Pediatric cardiac MRI: anatomy and function. *Pediatric Radiology* 2008; 38 (Suppl 2): S192-S199.

7. B. Enlargement of the posterior fossa.

Dandy-Walker variant is more common, accounting for a third of all posterior fossa malformations, but less severe than the malformation. Enlargement of the posterior fossa is not a feature. Cystic dilatation of the fourth ventricle with vermian dysgenesis is characteristic of both. Associated CNS anomalies, usually of the midline, are also seen, as is ventriculomegaly, although both are more common with Dandy-Walker malformation.

Dahner W. *Radiology Review Manual*, 6th edn, Lippincott Williams & Wilkins, 2007, pp. 280-281.

8. D. Arrange MRI, CT chest, and IBS.

The lesion described is probably an osteosarcoma. Ewing's sarcoma is high on the differential diagnosis, but is less often found in the metaphysis and usually has a soft-tissue component. Osteosarcomas commonly arise from the metaphysis (only 2-11% arise from the diaphysis). They are most common in the distal femur followed by the proximal tibia. If osteoid matrix is present on plain film, osteosarcoma is the diagnosis until proven otherwise. The appropriate action would be to refer to a regional orthopaedic centre for discussion at a multidisciplinary meeting with imaging followed by biopsy or surgery as thought appropriate. An MRI is used to evaluate local extent, the CT chest and IBS to search for pulmonary and bony metastases, respectively. Surgery is often performed after repeat imaging following the administration of neoadjuvant chemotherapy, when the oedema surrounding the tumour is less pronounced.

The findings are not particularly suspicious for NAI (option A). It is not safe to assume the appearances are caused by osteomyelitis and in any case more urgent investigation would be required to confirm such a diagnosis. A CT of the area might be useful but involves ionizing radiation, which MRI avoids; the MIBG scan would be appropriate for neuroblastoma, which is unlikely in this age group (90% occur before the age of 5) (option C). A metastasis is very unlikely in this age group.

Kan J, and Kleinman P. *Pediatric and Adolescent Musculoskeletal MRI*, Springer, 2007, 116-126.

9. D. The upper moiety ureter is associated with ureteroceles whereas the lower moiety ureter is associated with vesicoureteric reflux.

Ectopic ureter results when the ureteral bud fails to separate from the Wolffian duct and as a consequence is carried more caudally than normal. In females, the ectopic ureter can insert distal to the external sphincter, resulting in incontinence. Approximately 70% of ectopic insertion is associated with complete ureteral duplication.

According to the Weigert-Meyer rule of complete ureteral duplication, the ureteric orifice of the upper moiety inserts into the bladder medial and inferior to the lower moiety. The ureter draining the lower moiety is associated with Ureteroceles and Obstruction (note the vowels), whereas the lower pole moiety is associated with vesico-ureteric reflux. The obstructed upper moiety may not be visualized on IVU. The absence of upper pole calyx and displaced ('drooping' lower moiety calyces help in making the diagnosis.

Bercoff T, Lopez-Pereira F, Arjonilla A, and Gutierrez J. Anomalies of the distal ureter, bladder, and urethra in children: embryologic, radiologic and pathologic features. *Radiographics* 2002; 22: 1139-1164.

10. B. Longer dorsal duct draining via the minor papilla/shorter ventral duct draining via the major papilla.

Pancreas divisum is the most common congenital anomaly of the pancreatic duct and has a prevalence of 4–10% of the general population. Although it is usually asymptomatic and an incidental finding, it can lead to recurrent episodes of pancreatitis in children and adults. By definition, the dorsal and ventral ducts fail to fuse during embryological development, which results in the following features seen at MRCP: (a) a prominent dorsal pancreatic duct, which drains directly into the minor papilla, and (b) a ventral duct, which does not communicate with the dorsal duct, but joins with the distal bile duct to enter the major papilla (ampulla of Vater). Typically, the ventral duct is short and narrow, while the dorsal duct normally has a larger caliber. Anupindi SA. Pancreatic and biliary anomalies: imaging in 2008. *Pediatric Radiology* 2008; 38(2): S267–S271.

Patel HT, Shah AJ, Khandelwal SR, Patel HF, and Patel MD. MR cholangiopancreatography at 3.0 T. *Radiographics* 2009; 29: 1689–1706.

11. E. Aberrant left pulmonary artery.

Double aortic arch compresses the trachea anteriorly and the oesophagus posteriorly. Aberrant right subclavian (with a left-sided aortic arch) causes posterior indentation of the oesophagus, but no indentation of the trachea. An identical appearance is seen on the lateral view with a right-sided aortic arch and an aberrant left subclavian.

Aberrant left pulmonary artery commonly presents any time up to early childhood, with stridor, wheezing, recurrent infections, and feeding problems being amongst the most common symptoms. It can be associated with a PDA or ASD.

Donnelly L. *Fundamentals of Pediatric Radiology*, 1st edn, Saunders, 2001, p. 14.

Dahner W. *Radiology Review Manual*, 6th edn, Lippincott Williams & Wilkins, 2007, p. 603.

12. E. Medulloblastoma.

This is the most common malignant posterior fossa tumour in children, generally occurring before 10 years of age. The vast majority (85%) arise in the cerebellar vermis. They are hyperdense due to their high cellular content. Calcification is uncommon, occurring in up to 20% of cases. Pilocytic astrocytoma typically present as a cystic mass with an enhancing nodule. The most common location is the cerebellum, but they usually occur in other sites when associated with neurofibromatosis type 1. Haemangioblastomas are rare in children and even in the setting of von Hippel-Lindau syndrome typically manifest in early adulthood. Ependymomas are usually more heterogeneous owing to calcification, cystic change, and haemorrhage. The tumour arises from ependymal cells that line the ventricular system and central canal of the spinal cord. Brainstem gliomas are hypodense on CT and may show exophytic growth into the adjacent cisternal spaces. Brant WE and Helms CA. *Fundamentals of Diagnostic Radiology*, 3rd edn, Lippincott Williams & Wilkins, 2007, pp. 136–140.

13. C. To arrange a CT brain that night, followed by a skeletal survey the following morning.

A metaphyseal fracture in a non-ambulant child is due to NAI until proven otherwise. Of all the injuries described in NAI, none is more specific than the metaphyseal fracture. Royal College guidelines state that skeletal surveys should be performed by two radiographers and the films reviewed by a consultant radiologist before the child leaves the x-ray department in cases of suspected NAI. Thus, it is more appropriate that such a skeletal survey should be performed within normal hours, although usually within 24 hours of admission. Also, the guidelines state that any child under the age of 1 year who has evidence of physical abuse should undergo neuroimaging (as well as any child with evidence of physical abuse and encephalopathic

features/focal neurology/haemorrhagic retinopathy). Thus a CT brain is indicated. The guidelines infer this CT brain should be performed as soon as the child is stabilized following admission. IBs and follow-up imaging may be relevant depending on the circumstances. A 'babygram' (a film which includes the whole of the infant) is not appropriate.

At radiology trainee level it is important to remember that, due to the severe consequences for child and family of correctly/incorrectly making or missing the diagnosis of NAI, consultant involvement is necessary, both of the clinical and radiological teams.

Standards for Radiological Investigations of Suspected Non-accidental Injury, Intercollegiate report from the Royal College of Radiologists and Royal College of Paediatrics and Child Health, March 2008. Available at: http://www.rcpch.ac.uk/doc.aspx?id_Resource=3521.

14. B. Gartner duct cyst.

Anatomical location is useful in the differential diagnosis of perineurthral cysts. A Gartner duct cyst is a retention cyst arising from Wolffian (mesonephric duct remnant). It is typically located in the antero-lateral aspect of the vagina above the level of the pubic symphysis. It is usually solitary and less than 2 cm in size. At MRI, the lesion may appear hypo- or hyperintense on T1WI depending on whether the contents are simple fluid or haemorrhagic/proteinaceous. They do not displace or deform the urethra.

A Bartholin cyst is located in the posterolateral aspect of the lower vagina, at or below the level of the pubic symphysis. Skene cysts are located lateral to the external urethral meatus, below the level of pubic symphysis. It may be difficult to differentiate Bartholin and Skene cysts. Urethral diverticula communicate with the urethra whereas perineurthral cysts do not. A urethral caruncle manifests as T2 hyperintense soft tissue surrounding the external urethral meatus.

Chaudhari VV, Patel MK, Douek M, and Raman SS. MR imaging and US of female urethral and perineurthral disease. *Radiographics* 2010; 30: 1857–1874.

15. D. Duodenal-jejunal corkscrew appearance on an upper GI contrast study.

In individuals with malrotation, the mesenteric attachment of the midgut, particularly the portion from the duodenal-jejunal junction to the caecum, is abnormally short. The gut is therefore prone to twist counterclockwise around the superior mesenteric artery and vein—midgut volvulus. Options A to C are all imaging findings in malrotation, but not specifically that midgut volvulus has occurred. With regard to option E duodenal obstruction can, of course, be seen with midgut volvulus, but obstruction may also occur due to obstructive bands and there is also an increased risk of congenital duodenal anomalies in malrotation, such as duodenal atresia, stenosis, and webs. It is the finding of an abnormally located duodenal-jejunal flexure and a corkscrew appearance to the duodenum and proximal jejunum that is the most specific for malrotation complicated by midgut volvulus.

Applegate KE, Anderson JM, and Klatte EC. Intestinal malrotation in children: a problem-solving approach to the upper gastrointestinal series. *Radiographics* 2006; 26: 1485–1500.

16. D. Central line.

The tip of the central line is ideally situated superior to the level of the carina to ensure that it is not within the right atrium. Whilst placement inferior to this may be satisfactory, it can result in placement within the right atrium or coronary sinus, which are associated with an increased risk of complications. When assessing the ET tube in neonates, the tip should lie between the carina and the thoracic inlet, as more accurate placement is difficult given the size of the patient. UACs are divided into high and low lines. High lines should have their tip between T8 and T10. Low lines should be sited below L3. Lines should not be sited between T10 and L3 as they can cause

thrombosis of the mesenteric or renal vessels. UVCS pass superiorly into the portal vein, along the ductus venosus into the IVC.

Teele S, Emani S, Thiagarajan R, and Teele R. Catheters, wires, tubes and drains on postoperative radiographs of pediatric cardiac patients: the whys and wherefores. *Pediatric Radiology* 2008; 38: 1041–1053.

Donnelly L. *Fundamentals of Pediatric Radiology*, 1st edn, Saunders, 2001, pp. 27–29.

17. C. Inter-hemispheric subdural haematoma.

NAI is a difficult and controversial subject with no absolute pathognomonic features. It is, however, the leading cause of morbidity and mortality in abused children. Inter-hemispheric subdural haematoma has the highest specificity of abuse for any intracranial injury. Subarachnoid haemorrhage is also a much more common injury in NAI. Skull fractures are relatively common in both accidental and non-accidental injury; in addition, there are no fracture patterns that are specific for abuse, although fractures that cross sutures and bilateral fractures are more common in the setting of NAI. Skull radiography is preferred over CT for fracture assessment. Extradural haematoma is much more often accidental than inflicted and may result from relatively short-distance falls. Bilateral frontal enlargement of the subarachnoid space is a feature of benign external hydrocephalus.

Loneragan GJ, Baker AM, Morey MK, and Boos SC. Child abuse: radiologic-pathologic correlation. *Radiographics*, 2003; 23: 811–845.

18. C. ¹²³I-metaiodobenzylguanidine (MIBG) scan.

Owing to the high specificity and sensitivity in neuroblastoma, MIBG imaging has superseded the use of ^{99m}Tc bone scans for the detection of skeletal metastases in the majority of children with neuroblastoma, which take up the tracer in >90% of cases, and has been recommended by the last international consensus conference as a standard element of staging and response evaluation. False-negative scans may be observed in approximately 10% of neuroblastomas that do not concentrate MIBG. In addition, very small amounts of bone marrow tumour will often not be detected and therefore the MIBG scan must be supplemented with bilateral bone marrow biopsy. For those patients whose tumours are negative for MIBG uptake at diagnosis, the ^{99m}Tc MDP bone scan is the standard test recommended to evaluate skeletal metastases. However, the low specificity of this test and the difficulty in interpreting uptake in young children with actively growing bones make investigation of alternative methods preferable. Whole-body MRI is also a sensitive test for neuroblastoma tumours, including bone and bone marrow metastases, although the specificity is much lower than for MIBG.

MRI and CT are appropriate in the staging of neuroblastoma, but for the assessment of local invasion rather than bony involvement in particular. There currently is no consensus about the optimal imaging modality for assessing local disease. Both MRI and CT are routinely used, depending on local availability and the radiologist's preference. 18-FDG PET-CT imaging is not as sensitive as MIBG imaging for bony metastases, although it may be more sensitive for small soft tissue tumours and nodal metastases. The use of PET-CT is not at present well defined and delivers a high radiation dose.

Mathay KK, Shulkin B, Ladenstein R, Michon J, Giammarile F, Lewington V et al. Criteria for evaluation of disease extent by (123I)-metaiodobenzylguanidine scans in neuroblastoma: a report for the International Neuroblastoma Risk Group (INRG) Task Force. *British Journal of Cancer* 2010; 102(9): 1319–1326.

Brisse HJ, McCarville MB, Granata C, Krug KB, Wootton-Gorges SL, Kanegawa K et al. Guidelines for imaging and staging of Neuroblastic Tumors: Consensus Report from the International Neuroblastoma Risk Group Project. *Radiology* 2011 (May 17), doi: 10.1148/radiol.11101352 (epub ahead of print).

19.B. Diffuse fatty infiltration and fibrosis.

Pancreatic insufficiency is almost invariable in patients who have the delta F508 mutation for CF. The most commonly described imaging abnormality in patients with CF is diffuse fatty infiltration and fibrosis. While pancreatic cysts are described, their size does not usually exceed a few millimetres. Larger pancreatic cysts have only been described in a few patients and complete replacement of the pancreas by macrocysts is very unusual.

Ryan S and Finn S. Pancreatic replacement by cysts in cystic fibrosis. *Pediatric Radiology* 2008; 38: 1141.

20.B. Situs inversus.

The primitive truncus is a midline structure that persists to a degree in truncus arteriosus abnormality. During normal development the truncus divides into the aortic and pulmonary trunks, which then undergo 150° anticlockwise rotation. In situs inversus there is 150° clockwise rotation. Transposition of the great arteries (TGA) is characterized by 30° rotation, anticlockwise in D-TGA and clockwise in L-TGA. Double-outlet right ventricle displays 90° anticlockwise rotation.

Donnelly L. *Fundamentals of Pediatric Radiology*, Saunders, 2001, pp. 87–92.

Dahner W. *Radiology Review Manual*, 6th edn, Lippincott Williams & Wilkins, 2007, p. 603.

21.D. Caudal displacement of the cerebellar tonsils.

Chiari II is seen in all patients with open spinal dysraphisms, such as myelomeningocele. Lacunar skull (lucenshaded) is also associated with Chiari II. Cervicomedullary kinking is common to both, although more so with Chiari II. Caudal displacement of the cerebellar tonsils is a feature of Chiari I, whereas in Chiari II the vermis herniates into the foramen magnum and the tonsils are lateral to the medulla.

Tortori-Donati P and Rossi A. *Pediatric Neuroradiology*, Springer, 2005, pp. 172–184.

22.B. Hamstrings.

Avulsion fractures in the pelvis are generally uncommon injuries and are seen almost exclusively in adolescent athletes. They occur at the apophyses, which while growing are more prone to injury than the adjacent tendons. The hamstrings attach at the ischial tuberosity, Sartorius attaches at the anterior superior iliac spine, rectus femoris at the anterior iliac spine, the adductors at the symphysis pubis, and iliopectas at the lesser trochanter. Care should be taken not to mistake an old avulsion, which can produce irregularity, marked periostitis, and adjacent soft-tissue mineralization, for a more sinister lesion.

Donnelly LF. *Fundamentals of Pediatric Radiology*, Saunders, 2001, pp. 177–178.

23.A. Ultrasound of adrenal glands.

Congenital adrenal hyperplasia (CAH) is the most common cause of ambiguous genitalia. It causes virilization in females and precocious puberty in males. Most cases are caused by 21-hydroxylase deficiency resulting in elevated 17-hydroxy-progesterone level.

Enlarged adrenal glands, limbs over 20 mm in length and 4 mm width, with nodular contour and normal cortico-medullary differentiation are suggestive of CAH. Stippled echogenicity producing 'cerebriform' appearance is considered specific for CAH. Normal adrenal glands do not, however, exclude the diagnosis.

Chavhan GB, Parra DA, Oudjhane K, Miller SF, Babyn PS, and Pipi Salle FL. Imaging of ambiguous genitalia: classification and diagnostic approach. *Radiographics* 2008; 28, 1891–1904.

24. E. Duodenal web.

A duodenal web is classically associated with the 'windsock sign' seen on an upper GI contrast study. Over time, the web or diaphragm passively elongates as a result of continual peristalsis, to form the windsock configuration of an intraluminal duodenal diverticulum. Duodenal atresia is commonly associated with the 'double bubble' appearance on AXR. The atresia is most commonly just distal to the ampulla of Vater. Associated anomalies are common, such as congenital heart disease, Down's syndrome, and malrotation. Mild gut volvulus is usually a complication of malrotation. The AXR may be normal, gasless, or show signs of duodenal/high small bowel obstruction. The upper GI contrast study shows an abnormal position of the duodenal-jejunal flexure (to the right of midline) or duodenal obstruction in severe cases. More often the volvulus is intermittent, when the 'corkscrew' appearance is classical, due to clockwise twisting of the jejunum around the superior mesenteric artery.

Annular pancreas and preduodenal portal vein are exceedingly rare. In preduodenal portal vein (persistent left vitelline vein), the portal vein lies in an abnormal position anterior to the duodenum and may cause compression. However, in this entity, the primary obstruction is more usually due to an associated obstructing duodenal lesion, such as an intraluminal membrane or web, and not to the abnormal position of the vein.

Materne R. The duodenal windsock sign. *Radiology* 2001, 218, pp. 749–750.
Rao P. Neonatal gastrointestinal imaging. *European Journal of Radiology* 2006, 60, 171–186.

25. D. Beta-haemolytic streptococcal pneumonia.

This is the most common neonatal pneumonia and differs from other common patterns of pneumonia as it causes this pattern on CXR, whereas other neonatal pneumonias commonly cause high lung volumes and streaky perihilar densities. Transient tachypnoea of the newborn (TTN) and meconium aspiration syndrome also classically cause increased lung volumes and streaky perihilar density, although the radiographic appearance of meconium aspiration can also often be difficult to differentiate from beta-haemolytic streptococcal pneumonia. A useful differentiation is that pleural effusions are uncommon in meconium aspiration, but are commonly seen in beta-haemolytic streptococcal pneumonia. TTN is also characterized by rapid clearance and would not be expected to persist on serial radiographs. The other common cause for low lung volumes and granular densities described is surfactant deficiency. This would be very unlikely in an infant born at 38 weeks gestation.

Donnelly L. *Fundamentals of Pediatric Radiology*, Saunders, 2001, pp. 23–26.

26. A. Intracerebral cleft lined by gray matter connecting the lateral ventricle to the

subarachnoid space.

Schizencephaly can be defined as open or closed lip, depending on the presence of separation of the cleft walls. The remaining options describe lissencephaly, polymicrogyria, transmantle heterotopia, and subcortical band heterotopia, respectively. Transmantle heterotopia can potentially be confused with closed lip schizencephaly.

Tortori-Donati P and Rossi A. *Pediatric Neuroradiology*, Springer, 2005, pp. 100–138.

27. C. An atlanto-dens interval (ADI) of 6 mm.

There are appearances that are normal for a paediatric cervical spine, which would be considered pathological in an adult and of which it is important to be aware. Pseudo-subluxation at C2/3 and C3/4 is common (it was observed in 46% of patients less than 8 years old at C2/3 in one study and has been seen up to 14 years). The anterior aspects of the spinous processes of C1, C2, and C3 should line up within 1 mm of each other on flexion and extension

(assessed by drawing the posterior cervical line, a line from the anterior aspect of the spinous process of C1 to the equivalent point at C3). The anterior aspect of the spinous process of C2 is allowed to pass through, touch, or lie up to 1 mm behind the posterior cervical line in physiological subluxation.

The normal ADI (the distance between the anterior aspect of the dens and the posterior aspect of the ring of the atlas) in adults is 3 mm, but is normal up to 5 mm in children. 'Pseudo-Jefferson' fractures (pseudospread of the lateral masses of C1 on C2) can be seen on the peg view, and up to 6 mm of displacement is common up to 4 years old and may be seen in patients up to 7 years old. Anterior wedging of up to 3 mm of the vertebral bodies should not be confused with compression fracture. This finding can be profound at C3. Prevertebral swelling of 6 mm or less is considered normal at C3. Widening of prevertebral soft tissues in children can be due to expiration, and if suspected, a repeat lateral film in inspiration and mild extension should be performed.

Lustriin ES, Karakas SP, Ortiz AO, Cinnamon J, Castillo M, Vahesoon K et al. Pediatric cervical spine: normal anatomy, variants and trauma. *Radiographics* 2003; 23, 539–560.

28. D. Enlarged, calcified adrenals that maintain their normal triangular configuration.

Wolman disease is a rare, autosomal recessive, primary familial xanthomatosis with involvement and calcification of the adrenal glands. Deficiency of acid esterase or acid lipase results in lipid deposition in multiple organs, including the liver, spleen, lymph nodes, adrenal cortex, and small bowel. It has a poor prognosis. Most patients die within 6 months of life due to malabsorption. All the above-mentioned features are noted in Wolman disease but the most specific finding is enlarged, calcified adrenal glands that maintain their normal configuration.

Fulcher A, Lakshmana Das Narita, and Hingsbergen EA. Pediatric case of the day – Wolman disease (primary familial xanthomatosis with involvement and calcification of the adrenal glands). *Radiographics* 1998; 18: 533–535.

29. C. Neonatal hepatitis.

Physiological jaundice of the newborn usually resolves within 2 weeks and thus is unlikely to be the cause in this case. It is also unconjugated, as is jaundice secondary to hypothyroidism. Caroli's disease (type V of the Todani choledochal cyst classification) would typically have an abnormal ultrasound, demonstrating cystic dilatation of the intrahepatic bile ducts.

The key distinction in this question is between biliary atresia and neonatal hepatitis. The question stated that the ultrasound was normal and visualization of a normal-sized gallbladder has been said to favour neonatal hepatitis. However, 20% of patients with biliary atresia may have a normal sized gallbladder, which also empties after a feed. Despite this, in the presence of a suggestive clinical picture, an absent or small gallbladder in the fasting state, a gallbladder with irregular and echogenic walls, or a large gallbladder that does not empty post feed are highly suggestive of biliary atresia. Distinction can be clarified with a HIDA scan. In early biliary atresia prior to cirrhosis, there is rapid extraction of radionuclide from the bloodstream, which persists and accumulates in the hepatic parenchyma with failure of excretion into the gut. Thus, visualization of isotope activity within the gut excludes the diagnosis of biliary atresia. In severe or late biliary atresia, hepatocyte function eventually deteriorates, resulting in sluggish tracer uptake by the hepatocytes. Patients with neonatal hepatitis often have decreased parenchymal extraction and clearance of radioisotope from the bloodstream but tracer does reach the intestines.

Rao P. Neonatal gastrointestinal imaging. *European Journal of Radiology* 2006; 60, 171–186.

30. C. BPD.

Whilst surfactant deficiency is undoubtedly a feature of this case, the evolution of the clinical scenario indicates that a further condition is evolving to explain the findings and clinical condition. In this case the two likeliest conditions are BPD and PIE, both most commonly associated with immature lungs and both of which give bubbly lucencies on radiography. PIE is a feature of air leak phenomena which occur in stiff lungs and is due to either high airway pressure or alveolar overdistention causing passage of gas into the interstitial spaces. It is associated with other airleak phenomena such as pneumopericardium. BPD was originally described to occur in four stages, but the advent of refined ventilation, surfactant, and prophylactic administration of corticosteroids, have changed the typical progression. A complete discussion of these diseases is found in the article referenced below. BPD tends to develop more gradually than PIE (as described in the clinical vignette) and tends to occur later than PIE.

Agarons G, Courtney S, Stocker J, and Markowitz R. Lung disease in premature neonates: radiologic-pathologic correlation. *Radiographics* 2005; 25: 1047–1073.

31. C. Sturge Weber syndrome.

The gyrfiform low T2WI signal corresponds to cortical calcification, which in association with unilateral atrophy and leptomeningeal enhancement is characteristic of Sturge Weber syndrome, one of the neurocutaneous phakomatoses. Other findings include calvarial thickening and choroid plexus angiomata. Associated facial port wine stain in the distribution of the trigeminal nerve is classic.

Pope TL. *Aunt Minnie's Atlas and Imaging-Specific Diagnosis*, 3rd edn, Lippincott Williams & Wilkins, 2009, pp. 263–264.

32. C. Trochlea present before internal epicondyle.

The appearance of the ossification centres can be remembered by using the mnemonic CRITOE (Capitulum, Radial head, Internal epicondyle, Trochlea, Olecranon, and External epicondyle). These appear at years 1, 5, 5, 7, 10, and 11, respectively. This sequence is very important in the recognition of elbow fractures in children. The apparent appearance of the trochlea or olecranon before the internal (also called medial) epicondyle infers avulsion of the internal epicondyle into the joint space to pose as the not yet formed trochlea or olecranon.

Donnelly LF. *Fundamentals of Pediatric Radiology*, 1st edn, Saunders, 2001, pp. 175–176.

33. B. Juvenile granulosa cell tumour.

This is a sex cord stromal tumour arising from the granulosa-theca cells. They typically affect prepubescent girls and are unilateral. They are usually hormonally active (secrete oestrogen), resulting in precocious puberty. Granulosa cell tumours have a varied appearance on imaging. They may be completely solid with or without haemorrhagic or fibrotic changes, multilocular solid/cystic, or a completely cystic neoplasm. On T2WI they have a characteristic sponge-like appearance with innumerable cystic areas in a solid lesion of intermediate signal. Inhibin is the tumour marker used to monitor these lesions.

Sertoli–Leydig cell tumour is also hormonally active, but it results in virilization and hirsutism. Malignant epithelial neoplasms of the ovaries are extremely rare in prepubertal girls. Mature cystic teratoma is the most common type of ovarian neoplasm in the paediatric age group, containing derivatives of at least two of the three germ cell layers: ectoderm, mesoderm, or endoderm. Fibroma is rare in children.

Epelman M, Chikwava KR, Chauvin N, and Servaes S. Imaging of pediatric ovarian neoplasms. *Pediatric Radiology* 2011; 41(9): 1085–1099.

34.E. Duplication cyst.

The most common location for duplication cysts is in the terminal ileum. This is followed by oesophagus, duodenum, and stomach. Duplication cysts contain both mucosal and muscle layers. On ultrasound, the mucosa is represented by an inner echogenic line and the muscle as an outer hypoechoic layer. The cyst is usually anechoic, unless complicated by haemorrhage or infection. Lymphangiomas, mesenteric, and omental cysts are rare. On ultrasound, they are usually anechoic, unless complicated by debris, haemorrhage, or infection. The wall is usually thin and does not have the double layer associated with duplication cysts.

Ovarian cysts arise from the pelvis and will not have the layered wall appearance of a duplication cyst.

Rao P. Neonatal gastrointestinal imaging. *European Journal of Radiology* 2006; 60: 171–186.

35.A. Congenital lobar emphysema.

This has a lobar predilection with around 40% being found in the left upper lobe. Congenital lobar emphysema initially presents as an area of soft tissue density due to retained foetal pulmonary fluid. This resolves and is replaced by hyperlucency. Most present in the neonatal period with respiratory distress, but they can present later. Congenital cystic adenomatoid malformations (CCAM) do not show a lobar predilection, but can be found anywhere. They can be either air or fluid filled and consist of multiple cysts. CCAM are graded on the size of the cysts with type 1 lesions containing one or more large cysts, type 2 have numerous small cysts, and type 3 contain microscopic cysts, but appear solid at imaging. Congenital diaphragmatic hernias are also initially solid on plain radiography and only contain air if there is bowel present within the hernia and this contains air. This would obviously have continuity with the diaphragm and not be contained entirely within the upper lobe. Persistent PLE occurs when PLE fails to resolve after 1 week. As PLE is almost always seen in infants with surfactant deficiency being ventilated, it would not be in the differential in this case. Sequestrations are usually solid masses on plain film radiography, unless there has been a history of infection within the sequestration. Donnelly L. *Fundamentals of Pediatric Radiology*, Saunders, 2001, pp. 35–44.

36.C. Anechoic cystic mass anterior to sternocleidomastoid near the angle of the mandible.

The other options are typical locations for cystic hygroma, infantile haemangioma, thyroglossal cyst, and first branchial cleft cyst, respectively. The majority (75%) of branchial cleft cysts are remnants of the second branchial cleft. Cystic hygromas are lymphatic malformations (lymphangiomas) that result from blockage of lymphatic channels. Most present before 2 years of age. Most are slow growing, but can suddenly enlarge following infection or haemorrhage into the lesion. Infantile haemangiomas usually grow rapidly until 9–10 months of age, followed by spontaneous resolution, which can take up to 10 years. Thyroglossal cysts are remnants of the thyroglossal duct, which extends from the foramen caecum at the base of the tongue to the pyramidal lobe of the thyroid. The majority (65%) are infrahyoid. Turkington JRA, Paterson A, Sweeney LE, and Thornbury GD. Neck masses in children. *British Journal of Radiology* 2005; 78, 75–85.

37.B. Salter–Harris type 2 injury.

The Salter–Harris classification is used to describe fractures involving the physis when it is not yet fused. Involvement of the growth plate may cause arrest in growth, with the higher Salter–Harris numbers having a greater rate of complications. Type 2 is the most common (75% of physeal injuries). A useful mnemonic is SALTR.

Type 1 Slip: only the physis

Type 2 Above: a metaphyseal fracture extending to the physis, but not involving the epiphysis

- Type 3 Low: a fracture involving the epiphysis and physis but not the metaphysis
Type 4 Through: a fracture extending from the metaphysis, through the physis to involve the epiphysis
Type 5 Rammed: CRUSH injury to all or part of the physis

Dähnert W. *Radiology Review Manual*, 5th edn, Lippincott Williams & Wilkins, 2003, pp. 81–83.

38. C. Meckel Gruber syndrome.

All of the mentioned conditions are associated with multiple renal cysts, but the triad of bilateral enlarged cystic kidneys, occipital encephalocele, and polydactyly is diagnostic of Meckel Gruber syndrome. Bardet-Biedl syndrome is associated with enlarged cystic dysplasia of the kidneys with polydactyly.

Gupta P and Jain S. MRI in a fetus with Meckel-Gruber syndrome. *Pediatric Radiology* 2008; 38: 122.

Avni FE and Hall M. Renal cystic diseases in children: new concepts. *Pediatric Radiology* 2010; 40: 939–946.

39. B. Meconium plug syndrome.

This is a transient disorder of the neonatal colon characterized by delayed passage of meconium and proximal dilatation of the bowel. The obstruction is due to a colonic dysmotility and associated with a large meconium plug in the left colon. The colon may appear normal or distended proximal to the plug and small caliber distally. A water-soluble contrast enema is both diagnostic and therapeutic. If there is persistence of abdominal distension and/or failure to evacuate, then rectal biopsy may be needed to exclude Hirschsprung's disease.

Hirschsprung's disease is a disorder of the bowel resulting from absence of normal ganglionic cells in the Auerbach's and Meissner's plexuses. Aganglionosis always affects the rectum and extends proximally for a variable distance. Short segment disease occurs in the vast majority of cases, with the transition zone (the junction between the normal-sized distal aganglionic segment and the proximal dilated bowel) occurring in the region of the rectosigmoid. Contrast enema is used to delineate the level of the transition zone and care must be taken not to overfill the recto-sigmoid and thus mask the transition zone. Irregular, uncoordinated contractions in the aganglionic segment would more commonly be seen in the distal colon in Hirschsprung's disease than in a meconium plug syndrome.

Meconium ileus syndrome is a distal small bowel obstruction secondary to thick inspissated meconium in the ileum, usually associated with CF. Water-soluble contrast enema may be both diagnostic and therapeutic.

A small left colon syndrome is a subtype of meconium plug syndrome. Contrast enema shows an apparent transition zone at the splenic flexure. There is a normal-sized sigmoid colon, but a small descending colon, mimicking a microcolon, which becomes normal sized again around the splenic flexure. The caliber abnormality is therefore limited to the descending colon, which was not described in this case.

Colonic atresia is secondary to a vascular insult in utero and is extremely uncommon. A microcolon exists distal to the atretic segment.

Rao P. Neonatal gastrointestinal imaging. *European Journal of Radiology* 2006; 60: 171–186.

40. E. Extralobar sequestration.

Sequestrations are defined as lung tissue masses with no normal connection to the bronchial tree or pulmonary arteries. This diagnosis can often be difficult to make as extralobar sequestrations are associated with CCAM and congenital diaphragmatic hernia (CDH). The fact that the lesion is contained entirely within the thorax, with no abdominal connection described, means CDH is less likely. CCAM usually derive their blood supply from the pulmonary arteries.

Foregut duplication cysts would be expected to be hypoechoic on ultrasound and non-vascular. The differentiation between intralobar and extralobar sequestrations is more difficult. Previously the venous drainage has been used, with intralobar described as draining to the pulmonary veins and extralobar to systemic veins (IVC or azygous commonly). In actuality, the drainage is variable and the pleural covering the only constant difference, with intralobar having a separate visceral pleural covering, but extralobar having completely separate pleura. Extralobar sequestrations are more common in males and are usually in the left hemithorax (90%). They are also more commonly associated with other congenital abnormalities, such as cardiac malformations. Berrocal T, Madrid C, Novo S, Gutierrez J, Arjonilla A, and Gomez-Leon N. Congenital anomalies of the tracheobronchial tree, lung and mediastinum: embryology, radiology and pathology. *Radiographics* 2003; 24(1): e17.

41.B. Metachromatic leucodystrophy.

Leucodystrophies are dysmyelinating inherited white matter diseases, which are secondary to by deficiency of the lysosomal enzyme arylsulphatase A. The 'tigroid' pattern relates to sparing of perivascular white matter.

Table 5.1 outlines characteristic radiological findings of the major leucodystrophies.

Table 5.1 Characteristic radiological findings of the major leucodystrophies

Organelle	Disease	Radiological findings
Lysosome	Metachromatic leucodystrophy	U fibre sparing
	Krabbe disease	Thalamic and caudate nuclei high attenuation on CT
	Mucopolysaccharidosis	Well-defined high T2 signal foci in corpus callosum and basal ganglia
Peroxisome	X-linked adrenoleucodystrophy	Symmetrical peritrigonal and splenium high T2 signal
	MELAS	Peripherol contrast enhancement
Mitochondria	Canavan disease	Multiple cortical and subcortical infarct-like lesions
Unclassified	Alexander disease	U fibres preferentially affected
		Frontal lobe predilection
		Subcortical white matter affected early

Data from Cheon J-E, Kim I-O, Hwang YS, Kim KJ, Wang K-C, Cho B-K et al. Leukodystrophy in children: a pictorial review of MR imaging features. *Radiographics* 2002; 22: 461-476.

Cheon J-E, Kim I-O, Hwang YS, Kim KJ, Wang K-C, Cho B-K et al. Leukodystrophy in children: a pictorial review of MR imaging features. *Radiographics* 2002; 22: 461-476.

42.E. Widening of the joint space.

Explanation given with the answer to question 43.

43.B. Loss of overlap between the medial femoral metaphysis and acetabulum.

Perthes' disease and SUFE, along with transient synovitis and septic arthritis, are important paediatric causes of hip pain. The diagnosis of Perthes' disease and SUFE is usually made initially on plain film and it is important to be able to both pick up the abnormalities and to correctly attribute them to the correct disease process (Table 5.2).

Table 5.2 Diagnostic features of Perthes' disease and SUFE

Perthes' disease		SUFE
Demographics	2–12 years, M:F 5:1, previous trauma in 30%	10–14 years, M > F, often overweight
Bilateral?	5–10%	25%
Radiographic features (early to late)	Small, sclerotic femoral epiphysis Widening of joint space Demineralization Subchondral radiolucent crescent Subcortical fracture on frog leg lateral view Fragmentation of femoral head Femoral head cysts Coxa plana, coxa magna	Initial widening and irregularity of physis Demineralization can occur early but sclerosis occurs later Metaphyseal extrusion sign (see above) Line of Klein abnormal Frank slip (easier seen with frog leg lateral view) Fragmentation of femoral head (lateral) which can produce narrowing of physis on AP film

The answer to question 42 is widening of the joint space. This occurs early in Perthes' disease. There is widening of the physis initially in SUFE (in advanced slip the physis can appear narrowed), but loss of joint space rather than widening may occur late in the disease, secondary to chondrolysis. In question 42, answers A, C, and D are also features of SUFE. The line of Klein is the line along the lateral aspect of the proximal femoral metaphysis, which should normally intersect the proximal femoral epiphysis, but does not in SUFE.

The answer to question 43 is loss of overlap between the medial femoral metaphysis and acetabulum. This has been termed the 'metaphyseal extrusion' sign and is a subtle early finding in SUFE. Answers A, D, and E are signs of Perthes' disease, although apparent reduction in size of the femoral epiphysis can occur later in SUFE as the epiphysis slips more posteriorly. Demineralization is not a good discriminating factor. It is more associated with Perthes' disease; it can occur in SUFE, but sclerosis of the proximal metaphysis occurs later (metaphyseal blanch sign).

Data from: Hubbard AM. Imaging of pediatric hip disorders. *Radiologic Clinics of North America* 2001; 39: 721–732. Dähnert W. Data from Dähnert W. *Radiology Review Manual*, 5th edn, Lippincott Williams & Wilkins, 2003, pp. 49, 71–72.

Hubbard AM. Imaging of pediatric hip disorders. *Radiologic Clinics of North America* 2001; 39: 721–732. Dähnert W. *Radiology Review Manual*, 5th edn, Lippincott Williams & Wilkins, 2003, pp. 49, 71–72.

44.A. Inguinal canal.

The testes form in the retroperitoneum and descend through the inguinal canal into the scrotum. Failure to descend is known as cryptorchidism. A cryptorchid testis may be located at any point along the descent route. The most common location is the inguinal canal (70% of cases) followed by the prescrotal region, just beyond the superficial inguinal ring. On ultrasound, it is usually smaller and hypo or isoechoic compared to the normally located testis. Cryptorchidism is associated with an increased risk of malignancy even after correction.

Aso C, Enriquez G, Fite M, Toran N, Piro C, Piqueras J et al. Gray-scale and color Doppler sonography of scrotal disorders in children: an update. *Radiographics* 2005; 25: 1197–1214.

45.D. Hepatoblastoma.

This is the most common primary malignant tumour in children (approximately 80%). Most cases occur below the age of 3 years. Serum alpha-fetoprotein is elevated in 70–90%. The imaging features are as described. Calcification is seen in approximately 50%.

HCC is the next most common malignant liver tumour and has two peaks in childhood, at 2–4 years and 12–14 years. Serum alpha-fetoprotein is also elevated in approximately 80%. Imaging features are similar to those seen in an adult population, i.e. larger tumours are of heterogeneous echogenicity on ultrasound and on biphasic CT they show arterial enhancement with rapid washout on the portal venous phase.

Undifferentiated embryonal sarcoma (UES) is the third most common liver malignancy and is most common between the ages of 6 and 10 years. Serum alpha-fetoprotein levels are normal. The imaging hallmark of this tumour is the discrepancy between its appearance on ultrasound and that on CT. Ultrasound is used to confirm the solid nature of this tumour, which typically is isoechoic or hyperechoic. On CT, UES is seen as a well-circumscribed, multiseptate, fluid-attenuating lesion. Enhancement of solid-appearing septa and a pseudocapsule may be seen. Mesenchymal hamartoma is the second most common benign hepatic lesion (to haemangioma). It is usually seen under the age of 2 years. Serum alpha-fetoprotein is not elevated. The typical ultrasound appearance is a multiseptate, cystic mass. Less commonly, the solid component of the lesion can be more predominant, with multiple smaller cysts giving the lesion a Swiss-cheese appearance. The usual CT finding is of a multilocular cystic mass with enhancing septa of varying thickness.

Angiosarcoma is not usually seen in children, but is a rare, highly vascular and highly malignant, hepatic tumour of adults. Das CJ, Dhingra S, Gupta AK, Lyer V, and Agarwala S. Imaging of paediatric liver tumours with pathological correlation. *Clinical Radiology* 2009; 64: 1015–1025.

46.A. Send them home and reassure the parents. This radiograph has all the classic hallmarks of a viral pneumonia in a child. Air-trapping is common due to the small airways, which become occluded secondary to peribronchial wall oedema. There is no focal consolidation or pleural effusion seen, features that would indicate a bacterial pneumonia requiring antibiotics. In children it is not necessary to repeat imaging to ensure appearances resolve as long as the symptoms settle. Bilateral inhaled foreign bodies, causing the bilateral air-trapping, would be very unusual, especially in a well child. Respiratory consult would only be indicated if the symptoms failed to settle or there was a significant associated history, e.g. CF.

Donnelly L. *Fundamentals of Pediatric Radiology*, Saunders, 2001, pp. 44–52.

47.B. Sagittal suture.

Craniosynostosis refers to premature closing of sutures and is often present at birth. It may be primary or secondary to bone dysplasias or haemoglobinopathy, or as part of a generalized syndrome. Scaphocephaly is the most common craniosynostosis and results in a long skull. Brachycephaly arises from bilateral closure of the coronal suture, resulting in a short, tall skull. Unilateral fusion of the lambdoid suture is seen in plagiocephaly, giving a lopsided skull. Trigonocephaly is a forward-pointing skull from premature closure of the metopic suture. Intracranial closure of coronal, sagittal and lambdoid sutures gives rise to the cloverleaf skull, which may be associated with thanatophoric dysplasia.

Dahner W. *Radiology Review Manual*, 6th edn, Lippincott Williams & Wilkins, 2007, p. 178.

48.C. Bell clapper deformity predisposes to testicular torsion.

Testicular torsion is an emergency. If it is not corrected within 6 hours, testicular salvage is less likely. Torsion results initially in venous obstruction followed by arterial obstruction. The severity of testicular ischaemia depends on the duration and the degree of torsion (180–720°). Clinical differentiation between testicular torsion and epididymo-orchitis can be challenging.

Two types are described: intravaginal and extravaginal. 'Bell clapper' deformity is the term used to describe high attachment of the tunica vaginalis to the spermatic cord that leaves the testis free to rotate.

On ultrasound, the affected testis may have normal echogenicity in the early phase. In the later phase, the testis enlarges and demonstrates increased or heterogeneous echogenicity. An enlarged and torped spermatic cord may be visualized. Absence of blood flow in the affected testis, with normal flow on the asymptomatic side, is most specific for torsion. Some arterial flow may persist in incomplete torsion (less than 360°). Decreased or reversed diastolic flow on pulsed-wave Doppler assessment assists in the diagnosis in such cases.

Aso C, Enriquez G, Fite M, Toran N, Piro C, Piqueras J et al. Gray-scale and color Doppler sonography of scrotal disorders in children: an update. *Radiographics* 2005; 25: 1197–1214.

49. E. A pyloric channel length of 12 mm.

Ultrasound is the primary imaging modality used for the diagnosis of hypertrophic pyloric stenosis, although the criteria are generally applied to infants of 6 weeks and older. These include muscle thickness > 3 mm, pyloric channel length > 14 mm, pyloric thickness (serosa to serosa) > 10 mm, failure of the pylorus to open with pyloric elongation and displacement, as well as retrograde or hyperperistaltic gastric contractions. A pyloric ratio, which is the ratio of the wall thickness to the pyloric diameter, above 0.27 is stated to be 96% sensitive for the diagnosis. The standard measurements above are not always applicable to neonates and real-time assessment to look for passage of fluid from the stomach into the duodenum becomes more important.

Rao P. Neonatal gastrointestinal imaging. *European Journal of Radiology* 2006; 60: 171–186.

50. B. Persistent PIE.

Although alluded to in the clinical scenario, this should not be assumed to be the most likely diagnosis in the absence of the CT findings, as this is an extremely uncommon condition. The CT findings provide the diagnosis due to the linear densities within the cystic cavities representing the bronchopulmonary bundle surrounded by air within the interstitial space. This appearance is seen in over 80% of cases. The abnormality is often confined to a single lobe, but can be more widespread. Current optimal management is debated. Lesions increasing in size are thought to be best treated with surgical resection, with stable lesions often resolving over time with conservative management.

Donnelly L, Lacaya J, Ozelame V, Frush D, Strouse P, Sumner T, and Paltiel H. CT findings and temporal course of persistent pulmonary interstitial emphysema in neonates: a multi-institutional study. *American Journal of Roentgenology* 2003; 180(4): 1129–1133.

51. A. Multiple flow voids within the basal ganglia bilaterally.

The history and ethnic origin of the patient suggest moyamoya syndrome. This is an idiopathic progressive arteriopathy of childhood resulting in narrowing of the distal internal carotid arteries and lenticulostriate collateralization. This collateralization causes the multiple basal ganglia flow voids, likened to a 'puff of smoke' (moyamoya in Japanese) on angiography. Secondary causes of moyamoya collateralization include neurofibromatosis type 1, post-radiation therapy and sickle cell anaemia. Irregular beading of the extracranial internal carotid arteries is seen in fibromuscular dysplasia.

Osborn AG, Blasler SL, Salzman KL, Katzman GL, Provenzale J, Castillo M et al. *Diagnostic Imaging: Brain*, Amirsys, 2004, 1–4: 42–45.

52. B. Osteochondritis dissecans.

This disease is thought to represent a fracture secondary to avascular necrosis of an area of subchondral bone and cartilage, and peak incidence is at 12–13 years of age. Repetitive trauma, ischaemia, and familial tendency are common predisposing factors. In the knee, 75% of cases involve the posterolateral aspect of the Medial femoral condyle, hence the mnemonic LA ME. The disease is bilateral in one-third of patients. A purely cartilaginous fragment will go unrecognized on plain film; a bony fragment and its donor site will not. Instability on MRI is suggested by fragments > 1 cm, cysts larger than 5 mm within the donor site, high T2WI signal between the donor site and fragment (even if the cartilage is intact), and loose bodies within the joint.

Distal femoral cortical irregularity (also referred to as cortical desmoid) is seen as a defect in the posterior aspect of the medial cortex of the distal femoral metaphysis, 1–2 cm proximal to the physis (at the attachment of adductor magnus). It appears low signal on T1WI and high signal on T2WI sequences. Plain film may show an ill-defined or scalloped appearance and may occasionally mimic an aggressive lesion (it is benign).

Sinding-Larsen-Johansson disease represents osteochondrosis at the site of attachment of the patellar tendon to the patella (inferior pole). Osgood-Schlatter disease represents apophysitis at the site of attachment of the patellar tendon to the tibia, namely the anterior tibial tubercle. Both are causes of knee pain and are associated with activity and repetitive traction microtrauma. An avulsion of the anterior tibial spine is the paediatric equivalent of an ACL tear (the chondro-osseous tibial spine is the weakest part of the ACL complex prior to physal closure). MRI reveals a low signal T1WI line through the anterior tibial spine.

Sanchez R and Strouse PJ. The knee: MR imaging of uniquely pediatric disorders. *Radiologic Clinics of North America* 2009; 47: 1009–1025.

53. C. The pudendal nerve and internal pudendal vessels pass through the lesser sciatic foramen. There are several potential pathways of extrapelvic spread of pelvic disease. Lateral extension into the gluteal region occurs through the sciatic foramina. It is important to identify extrapelvic spread, as combined trans-abdominal and trans-gluteal surgery may be required. Knowledge of gluteal anatomy is also essential for trans-gluteal biopsy and drainages.

The greater and lesser sciatic notches are noted in the posterior border of the innominate bone separated by the ischial spine.

The greater sciatic foramen (GSF) is bounded antero-superiorly by the greater sciatic notch, postero-superiorly by the sacrum, and inferiorly by the sacrospinous ligament. The piriformis muscle arises from the ventral aspect of the sacrum and passes through the GSF to insert into the greater trochanter. It divides the GSF into two compartments. The suprapiriformis foramen transmits the superior gluteal vessels and nerves. The infrapiriformis foramen transmits the inferior gluteal vessels and nerves, pudendal and sciatic nerves.

The lesser sciatic foramen (LSF) is bounded anteriorly by the lesser sciatic notch, superiorly by the sacrospinous ligament, and postero-inferiorly by the sacrotuberous ligament. The obturator internus tendon, the pudendal nerve, and the internal pudendal vessels pass through the LSF.

Tan CH, Vikram R, Boonsirirakamchai P, Faria SC, Chamsangavej C, and Bhosale PR. Pathways of extrapelvic spread of pelvic disease: imaging findings. *Radiographics* 2011; 31: 117–133.

54. C. The umbilical cord inserting at the apex of the hernia.

Omphalocele is the total failure of the midgut to return to the peritoneal cavity during the tenth week of gestation. The contents may vary from a single loop of small bowel to the entire GI tract, including the liver. An omphalocele can be differentiated from a gastroschisis (rupture

of the abdominal wall) because in an omphalocele, the herniated structures are covered by peritoneum and amnion, and the umbilical cord inserts at its apex. In gastroschisis, there is a normally positioned umbilicus and the hernia is through a paraumbilical defect. Because this (probably ischaemic) rupture of the abdominal wall occurs after the bowel has returned to the peritoneal cavity, the protruding viscera are not covered in peritoneum. The contents of the hernia in gastroschisis include stomach, midgut, and occasionally portions of the urinary tract. In omphalocele, there may be associated congenital cardiac anomalies and there is also an association with Beckwith-Wiedemann syndrome. There is a low incidence of additional anomalies in gastroschisis.

Blickman H. *Pediatric Radiology: The Requisites*, 2nd edn, Mosby, 1998, Ch 4.

55. C. Pulmonary valve hypoplasia with a VSD and overriding aorta.

These are the features of tetralogy of Fallot. Even in the absence of radiology this represents the most common form of congenital cyanotic heart disease. To help characterize congenital heart disease there are a number of features to note on the radiograph as well as clinically. The presence of cyanosis excludes coarctation, which does not cause cyanosis. Truncus arteriosus (and total anomalous pulmonary venous return (TAPVR)) are associated with increased pulmonary flow, not reduced, as present in this case. Pulmonary valve atresia with an intact ventricular septum does have reduced pulmonary flow, but would present earlier than four days and the heart is typically grossly enlarged, as in this anomaly there is no forward flow of blood out of the right ventricle. D-transposition of the great arteries is classically described as giving an egg-on-a-string appearance due to the narrowed superior mediastinum caused by the abnormal rotation of the great vessels. This appearance is seldom seen as D-transposition presents early with cyanosis and is surgically corrected. The most common CXR appearance in an infant is a normal CXR. The pulmonary vascularity on the radiograph is either normal or increased, not decreased.

Donnelly L. *Fundamentals of Pediatric Radiology*, Saunders, 2001, pp. 74–92.

56. B. Calcification.

This is the most specific feature of retinoblastoma and is apparent in 95% of cases. Other features of retinoblastoma include hyperattenuating mass extending into the vitreous and secondary retinal detachment. Contrast enhancement is seen in <30% of cases. The globe is normal sized. The non-neoplastic causes of leucocoria, the so-called pseudoretinoblastomas, include persistent hyperplastic primary vitreous (PHPV), Coats' disease, and toxocara endophthalmitis. CT findings in PHPV include micro-opticoma and an enhancing retrolental mass. Coats' disease is a vascular malformation of the retina and presents with a hyperattenuating globe and an enhancing subretinal exudate on CT. CT features of toxocara are non-specific and similar to Coats' disease. Secondary retinal detachment may be seen. None of the pseudoretinoblastomas exhibit calcification.

Chung EM, Specht CS, and Schoeder JW. Pediatric orbit tumors and tumorlike lesions: neuroepithelial lesions of the ocular globe and optic nerve. *Radiographics* 2007, 27, 1159–1186.

57. C. Posterior dislocation and medial epicondyle fracture.

The elbow is the most commonly dislocated joint in children (in adults the shoulder and interphalangeal joints are more common). A supracondylar fracture of the elbow is more common in children (65% of elbow fractures) than in adults, who generally suffer a radial head injury (50%). However, in both groups of patients, if dislocation occurs it tends to be posterior dislocation of the radial head and ulna with respect to the distal humerus (85–90%). The most common fracture seen in association with elbow dislocation in children is a fracture of the medial epicondyle or separation of the medial epicondyle. The second most common fracture involves

the radial head and neck. In terms of total paediatric elbow fractures, those involving the lateral epicondyle (15%) are next most common after the supracondylar fracture; medial epicondyle fractures comprise approximately 10%.

Rogers LF. *Radiology of Skeletal Trauma*, 3rd edn, Churchill Livingstone, 2001, pp. 683–778. Manaster BJ, May DA, and Disler DG. *Musculoskeletal Imaging: The Requisites*, 3rd edn, Mosby, 2007, pp. 117–125.

58.A. Congenital megacalyces

This is a rare developmental abnormality of the renal medulla. Imaging demonstrates dilated, multifaceted, or polygonal calyces as opposed to spherical calyces of obstructive hydronephrosis. In addition, the infundibula, renal pelvis, and ureter are normal in calibre in congenital hydronephrosis. The affected kidneys may demonstrate cortical thinning but the renal function is preserved.

Bekele W and Sanchez TR. Congenital megacalyces presenting as neonatal hydronephrosis. *Pediatric Radiology* 2010; 40: 1579.

59.C. Pancreatic duct dilatation.

In cases of acute pancreatitis in children, the echogenicity of the pancreas on ultrasound is not a helpful diagnostic feature and pancreatic enlargement is absent in 50% of the patients. The most useful diagnostic feature is dilatation of the pancreatic duct (>1.5 mm at 1–6 years of age, >1.9 mm at 7–12 years, and >2.2 mm at 13–18 years).

Pancreatic duct dilatation may also be seen in chronic pancreatitis. Pancreatic atrophy and parenchymal calcifications are more typically associated with chronic disease.

Nievesstein RY, Robben SGF, and Blickman JG. Hepatobiliary and pancreatic imaging in children – techniques and overview of non-neoplastic disease entities. *Pediatric Radiology* 2011; 41: 55–75.

60.B. Type B.

Tracheoesophageal fistulae are classed depending on the communications present between the trachea and the oesophagus. In types A–D the mid-portion of the oesophagus is absent. Type A are not truly fistulae, but consist of an absence of the mid-portion of the oesophagus. In type B the proximal oesophageal bud communicates with the trachea and in type C it is the distal bud that has a tracheal fistula. Type C is the most common subtype. Both proximal and distal buds have fistulous connections with the trachea in type D. Type E (or H type) tracheoesophageal fistulae have complete trachea and oesophagus with a fistulous connection between them resembling the letter H.

Dahner W. *Radiology Review Manual*, 6th edn, Lippincott Williams & Wilkins, 2007, 806–808.

61.C. Langerhans cell histiocytosis (LCH).

The radiographic description is typical for skull involvement in LCH. The bevelled edge results from uneven destruction of the inner and outer skull tables. They are more likely to present with pain than any other lesion. Marginal sclerosis may be seen with healing lesions. Epidermoids are oval-shaped lytic lesions, but tend to have sclerotic margins. Neuroblastoma metastases are also lytic lesions, but with a sunburst periosteal reaction. Sutural diastasis may be seen due to dural involvement. Haemangiomas exhibit a coarse trabecular pattern radiating from an oval defect. Osteomas appear as a dense homogeneous focus.

Willatt JM and Quaghebeur G. Calvarial masses of infants and children. a radiological approach. *Clinical Radiology* 2004; 59: 474–486.

62. E. None of the above.

The correct answer is to do nothing. This is the classical description of a non-ossifying fibroma (NOF). These and fibrous cortical defects are common in children and adolescents, and are usually a painless, incidental finding. They are eccentric, well-defined, cortically-based lesions with marginal sclerosis. They can be expansile. They are most common in the femur and tibia. Fibrous cortical defects measure less than 2 cm whereas NOFs are larger. They routinely heal by sclerosis and disappear. An IBS can show uptake during healing and a CT scan can show apparent cortical breakthrough. Thus the correct management is to do nothing. If there are atypical features, such as pain or periostitis, then additional investigation is indicated.

Helms C. *Fundamentals of Skeletal Radiology*, 3rd edn, Elsevier, 2005, 16–17.

63. B. CF.

Bilateral seminal vesicle agenesis is frequently associated with bilateral agenesis of the vas deferens and mutations in the CF transmembrane conductance regulator gene (64–73%). It is thought to be related to luminal obstruction by thick secretions. Bilateral agenesis of the vas deferens is seen in 99% of CF in males. The affected patients usually have normal kidneys. Unilateral seminal vesicle agenesis and seminal vesicle cyst are commonly associated with ipsilateral renal agenesis. Bilateral calcified vas deferens is commonly seen in diabetics. Kim B, Kawashima A, Ryu J, Takahashi J, Hartman RP, and King BF Jr. Imaging of the seminal vesicle and vas deferens. *Radiographics* 2009; 29: 1105–1121.

64. C. Water-soluble contrast enema.

This is rarely, if ever, indicated in the acute phase of necrotizing enterocolitis (NEC). It may be used for the evaluation of the presence of strictures, usually approximately 6–12 months after the acute phase of NEC.

Supine AXR is the primary method used to evaluate NEC. A 'jumbled' pattern may be seen secondary to bowel wall oedema, which either compresses the lumen in some areas or causes an ileus appearance in other areas. Pneumatosis may be seen, which is either 'bubbly' or linear. This can lead to air in the portal venous system, which does not appear to alter the morbidity or mortality. Perforation may occur and this may be demonstrated on the supine AXR by Rigler's sign (air on both sides of the bowel wall) or the 'football sign' (air outlining the falciform ligament). The left lateral decubitus and supine cross-table AXRs may both be used to detect small quantities of free air. Abdominal ultrasound may be helpful in the acute setting of NEC, as it can depict intra-abdominal fluid, bowel wall thickening, assess bowel wall perfusion, and may also detect small quantities of free air and portal venous gas.

Epeleman M, Daneman A, Navarro OM, Morag I, Moore AM, Kim JH, Faingold R, Taylor G, and Gerstle JT. Necrotizing enterocolitis: review of state of the art imaging findings with pathologic correlation. *Radiographics* 2007; 27: 285–305.

65. B. Partial anomalous pulmonary venous return (PAPVR).

This most commonly involves the right superior pulmonary vein, but in this case involves the inferior vein. This condition may remain asymptomatic for a number of years, depending on the amount of blood that returns anomalously. PAPVR can drain into the superior vena cava (SVC), right atrium, or IVC on the right and into the brachiocephalic vein or coronary sinus on the left. Scimitar syndrome is a subtype of PAPVR that is associated with ipsilateral lung hypoplasia (hence alternative name hypogenetic lung syndrome) and occasionally dextrocardia. As noted in the history, the lungs were normal. Extralobar sequestrations have aberrant pulmonary arterial supply, not present in this case. Total anomalous pulmonary venous return presents in

the neonatal period, commonly with cyanosis and plethoria on CXR. Patient survival depends on the presence of an ASD or PDA. No atrial abnormalities were noted to indicate cor triatriatum, although this is another disorder in the spectrum of pulmonary venous developmental anomalies. Dillman J, Yarram S, and Hernandez R. Imaging of pulmonary venous developmental anomalies. *American Journal of Roentgenology* 2009; 192(5): 1272–1285.

66. D. Pleomorphic adenoma.

This is the most common benign salivary gland tumour in children and usually appears in later childhood or adolescence. The tumour originates in the parotid gland in up to 90% of cases. Haemangiomas are the next most common benign lesion. They are usually seen in the first 6 months of life and have a female predilection. They are hypoechoic and display a variable degree of abnormal vascularity. Parotitis is usually due to mumps and results in a tender gland, which is diffusely enlarged with a heterogeneous echotexture on ultrasound. Warthin tumour is a well-circumscribed cystic solid lesion, usually towards the tail of the parotid gland. It is the most common lesion to manifest as multifocal or bilateral masses. Primary lymphoma of the salivary glands is rare, but most often involves the parotid. Ultrasound will show an enlarged, diffusely infiltrated gland.

Garcia CJ, Flores PA, Arce JD, Chuqui B, and Schwartz DS. Ultrasonography in the study of salivary gland lesions in children. *Pediatric Radiology* 1998; 28: 418–425.
Lowe LH, Stokes LS, Johnson JE, Heller RM, Royal SA, Wushensky C et al. Swelling at the angle of the mandible: imaging of the pediatric parotid gland and periparotid region. *Radiographics* 2001; 21: 1211–1227.

67. D. Diaphyseal aclasia.

The description is classic for multiple hereditary osteochondromas/exostoses, also known as diaphyseal aclasia.
Osteochondromas are the result of displaced growth plate cartilage, which causes lateral bone growth from the metaphysis. They typically point away from the epiphysis. There is continuity of the normal marrow, cortex, and periosteum between the exostosis and the host bone. The cartilage cap, which is the source of growth, may have some chondroid matrix, but the appearance is otherwise of a deformed but normal bone. They are normally found in the extremities, with 36% around the knee. Their growth normally ceases at skeletal maturity.
Symptoms are related to pressure effects on adjacent neural or vascular structures. Less than 1% of solitary osteochondromas undergo malignant transformation to chondrosarcoma. Findings that should alert to this are destruction of exostosis bone, destruction of matrix in the cartilage cap, irregular or thick (>2 cm in adults, >3 cm in children) cap, or growth of the cap after skeletal maturity.

Multiple hereditary osteochondromatosis is an uncommon autosomal dominant condition. Patients present with multiple osteochondromas, which cause short stature. The elbow and wrist joints are often deformed. There is a higher risk of malignant transformation than in solitary osteochondromas, probably 2–5%.

Ollier disease is the presence of multiple enchondromas and Maffucci syndrome requires, in addition, multiple soft-tissue haemangiomas. Morquio and Hunter syndromes are mucopolysaccharidoses, with their own musculoskeletal abnormalities, which often make an appearance in exams.

Master BJ, May DA, and Disler DG. *Musculoskeletal Imaging: The Requisites*, 3rd edn, Mosby, 2007, pp. 445–450.
Wootton-Gorges SL. MR imaging of primary bone tumours and tumour-like conditions in children. *Radiologic Clinics of North America* 2009; 47: 957–975.

68. C. Intercornual distance of more than 4 cm. Incomplete fusion of the Mullerian ducts results in bicornuate uterus. MRI demonstrates divergent uterine horns with an external fundal cleft that is more than 1 cm deep and an intercornual distance of more than 4 cm. In bicornuate bicolis uterus, two separate cervical canals are seen. This is distinguished from uterus didelphys by a greater degree of fusion between the horns in the lower uterine segment. Septate uterus results from incomplete septal resorption following Mullerian duct fusion. It is the most common uterine anomaly (55%). At MRI, the external fundal contour may be convex, flat, or minimally concave (less than 1 cm deep). MRI is also useful in characterizing the type (fibrous/muscular) and extent of the septum. Differentiation between bicornuate and septate uterus is important, as septate uterus is amenable to surgical management. Steinkeler JA, Woodruff CA, Lazarus E, and Hillstrom MM. Female infertility: a systematic approach to radiologic imaging and diagnosis. *Radiographics* 2009; 29: 1353–1370.

69. B. Gastric mucosa.

The most sensitive and specific evaluation for a Meckel's diverticulum is a ^{99m}Tc pertechnetate scan. This is positive only if gastric mucosa is present (in approximately 20% of patients). However, ectopic gastric mucosa is present in nearly all cases of Meckel's diverticulum that bleed, as it is the ulcerated ectopic gastric mucosa that is the source of the haemorrhage. Ectopic pancreatic and colonic mucosa can occur in a Meckel's diverticulum, but are not typically associated with haemorrhage. Ectopic thyroid tissue is not usually found in a Meckel's diverticulum. Other complications of a Meckel's diverticulum include obstruction (either volvulus or intussusception) and diverticulitis.

Blickman H. *Pediatric Radiology: The Requisites*, 2nd edn, Mosby, 1998, Ch 4.

70. D. Thymic/nodal malignant infiltration.

The first step in this question is to localize the lesion. The posterior displacement of the trachea indicates an anterior mediastinal position. It is then necessary to consider the common causes of anterior mediastinal masses in children, which are: normal thymus and thymic/nodal infiltration (leukaemia, lymphoma), with other causes (lymphangioma and teratoma) being much less common. A normal thymus would not be expected to cause significant posterior displacement of the trachea. On plain film it would not be possible to differentiate thymic infiltration from anterior mediastinal nodal infiltration. TB in children would be uncommon in the anterior mediastinum, especially when no abnormality is noted in the hila.

Adam A and Dixon A. *Granger and Allison's Diagnostic Radiology. A textbook of medical imaging*, Vol 2, 5th edn, Churchill Livingstone, 2008, Ch 64.

71. E. Delayed sulcation.

Signs of ACC include absence of the cavum septum pellucidum, colpocephaly, high-riding third ventricle, and widening of the inter-hemispheric fissure. ACC is reported to be isolated in <10% on foetal MRI imaging. Sulcation delay is present in most fetuses with ACC (particularly those imaged at <30 weeks gestation), including those with good neurodevelopmental outcome, implying a global white matter dysgenesis. Periventricular nodular heterotopia and parenchymal T2WI signal hypointensity are usually seen in association with abnormal sulcal morphology. Associated posterior fossa abnormalities are also common, with cerebellar hemispheric abnormalities seen more than abnormalities of the vermis. Brainstem abnormalities typically occur in association with a cerebellar abnormality.

Tang PH, Bartha AJ, Norton ME, Barkovich AJ, Sherr EH, and Glenn OA. Agnesis of the corpus callosum: an MRI imaging analysis of associated abnormalities in the fetus. *American Journal of Neuroradiology* 2009; 30: 257–263.

72. B. Achondroplasia.

This question tests knowledge of the severe skeletal dysplasias. Achondroplasia is the most common cause of dwarfism and is hereditary. The humeri and femora are more profoundly affected than the other long bones, although the entire skeleton is abnormal. Narrowing of the interpedicular distance as one progresses caudally down the spine is unique to this condition. Other features include a large skull with a small skull base, square iliac wings with a 'champagne-glass' pelvic cavity, and widened metaphyses.

Thanatophoric dysplasia results in early death. Features include severe platyspondyly and 'telephone receiver' femora. Chondrodysplasia punctata results in stippled epiphysis and rhizomelic dwarfism. Jeune syndrome (asphyxiating thoracic dysplasia) results in respiratory distress, very short ribs, metaphyseal irregularity/beaking, and trident acetabulum. Cleidocranial dysplasia is characterized by lack of development of the pubic bones bilaterally. There is also absence or hypoplasia of the clavicles and the presence of wormian bones in the skull.

Markowitz RL and Zackai E. A pragmatic approach to the diagnosis of pediatric syndromes and skeletal dysplasias. *Radiologic Clinics of North America* 2001; 39: 791–802.

Donnelly LF. *Fundamentals of Pediatric Radiology*, Saunders, 2001, pp. 197–199.

73. A. Enlarged ovary.

Ovarian torsion can occur in all age groups, with the highest prevalence in the reproductive age group. Large heavy cysts and cystic neoplasms commonly predispose to ovarian torsion. Torsion of normal ovaries is unusual but more common in adolescents. Clinical symptoms are often non-specific and therefore imaging is routinely requested.

On ultrasound, an enlarged ovary is the most constant finding. The enlarged ovary may be heterogeneous due to haemorrhage and oedema. Other findings include multiple small cysts aligned in the periphery of the enlarged ovary (string of pearls sign), coexistent mass, pelvic free fluid, and twisted ovarian pedicle. Benign cystic teratoma is the most common tumour predisposed to ovarian torsion.

Absent arterial flow is described as the classic colour Doppler finding. However, the most frequent Doppler finding is decreased or absent venous flow with or without reduced arterial flow. A twisted ovarian pedicle with a 'whirlpool' sign is a useful finding on colour Doppler.

Chang HC, Bhatt S, and Dogra VS. Pearls and pitfalls in diagnosis of ovarian torsion. *Radiographics* 2008; 28: 1355–1368.

74. E. Peutz-Jegher's syndrome.

This is an autosomal dominant disease with incomplete penetrance characterized by intestinal polypoid and mucocutaneous pigmentation. It is the most frequent of the polypoid syndromes to involve the small intestine. When symptomatic, the most common presentation is abdominal pain (due to small bowel intussusception in up to 50%). There may also be GI haemorrhage. There is an increased risk of malignancy of the GI tract, pancreas, and breast, even though the polyps are hamartomas.

Cronkhite-Canada syndrome is non-neoplastic, non-hereditary inflammatory polypoid associated with ectodermal abnormalities. It usually occurs in the middle-aged to elderly and the polyps are more common in the stomach and colon than in the small bowel. Intussusception is not a typical presentation.

Gardner syndrome is an autosomal dominant disease characterized by a triad of colonic polypoid, osteomas, and soft-tissue tumours (including desmoid tumours). Age at presentation is 15–30 years. The location of the polyps is colon (100%), duodenum (90%), stomach (5–58%), and the remainder of the small bowel (<5%). Small bowel intussusception is therefore a very rare

presentation. There is a very high risk of malignant transformation of the colonic polyps if left untreated. Treatment is prophylactic total colectomy.

Familial adenomatous polyposis syndrome is an autosomal dominant disease. The polyps start to appear around puberty and have a similar distribution/location to those in Gardner syndrome. Again there is a high risk of malignant transformation of these adenomatous polyps.

Cowden disease is multiple hamartoma syndrome. It causes hamartomatous neoplasms of the skin and mucosa, GI tract, bones, CNS, eyes, and genitourinary tract. There may be associated malignant tumours of the breast and thyroid.

Dahner W. *Radiology Review Manual*, 3rd edn, Williams and Wilkins, 1996, Ch Gastrointestinal Tract.

75.A. Posterior rib fracture.

Metaphyseal corner fractures (or bucket handle fractures) and posterior rib fractures are the most specific for NAI. The other injuries given in the stem are also worrisome for NAI, particularly when observed in infants. Posterior rib fractures are sometimes relatively occult on plain film and scintigraphy is more sensitive. They occur when the chest is squeezed tightly, e.g. when a child is shaken. Shaking can also result in a thoraco-lumbar compression fracture. Spiral fractures of long bones are suspicious in infants, but in ambulatory children the 'toddler's' spiral fracture of the tibia is common and often has no memorable preceding trauma.

Duodenal haematoma and jejunal perforation are both recognized sequelae of NAI: the small bowel is the most injured organ in child abuse.

Loneragan GJ, Baker AM, Morey MK, and Boos SC. Child abuse: radiologic-pathologic correlation. *Radiographics* 2003; 23: 811-845.

1. A 9-year-old male presents to the paediatric A&E department with a history of increasing drowsiness over the last 24 hours. Neurological assessment reveals that there is absence of upward gaze. A CT brain is requested which reveals hydrocephalus, with marked dilatation of the lateral and third ventricles. The fourth ventricle is unremarkable and there is obliteration of the ambient cistern due to mass effect from a hyperdense mass noted posterior to the third ventricle. This mass has some central areas of calcification. There is no evidence of haemorrhage. An MRI is carried out following insertion of a shunt to decompress the ventricles. On sagittal sequences a lesion is located between the splenium of the corpus callosum and the tectal plate, which exerts mass effect. This lesion is of intermediate signal intensity on both T1WI and T2WI, and displays avid contrast enhancement. Enhancing meningeal lesions are also noted in the spinal cord, indicating seeding. What is the most likely diagnosis?

- A. Pituitary teratoma.
- B. Meningioma.
- C. Pineoblastoma.
- D. Germioma.
- E. Pineal cyst.

2. A patient presents with recent onset neurological symptoms suspicious of an acute presentation of multiple sclerosis (MS). Which of the following anatomical sites of plaque involvement is least consistent with this?

- A. Corpus callosum.
- B. Spine involvement in the absence of brain involvement.
- C. Cerebral cortex.
- D. Symmetrical involvement of cerebral white matter.
- E. Floor of the fourth ventricle.

3. A 45-year-old female patient is referred to you with a history of mild confusion and new onset seizures. This patient has a history of breast cancer and is currently undergoing chemotherapy following a wide local excision with axillary radiotherapy. The patient has a low-grade pyrexia and a low neutrophil count. An MRI reveals a solitary lesion in the right frontal lobe, which is low/intermediate signal on T1WI and high signal on T2WI. The lesion demonstrates ring enhancement. Diffusion-weighted imaging (DWI) reveals slightly increased signal on B1000 imaging, with increased signal on B0 imaging, and this area is bright on the apparent diffusion coefficient (ADC) map. What is the most likely diagnosis?
- Abscess.
 - Metastasis.
 - Glioblastoma multiforme.
 - Infarct.
 - Radiotherapy change.
4. A 69-year-old lady was admitted 10 days ago following an acute intracerebral haematoma diagnosed on CT. What are the most likely radiological findings on the follow-up MRI scan of brain?
- Haematoma hypointense to grey matter on T1WI, hyperintense on T2WI.
 - Haematoma hyperintense to grey matter on both T1WI and T2WI.
 - Haematoma hyperintense to grey matter on T1WI, hypointense on T2WI.
 - Haematoma hypointense to grey matter on both T1WI and T2WI.
 - Haematoma isointense to grey matter on both T1WI and T2WI.
5. A 40-year-old man is being investigated by the neurologists for new onset epilepsy. An electroencephalogram (EEG) indicates an epileptogenic focus in the left temporal lobe. An MRI is carried out. The hippocampal structures are unremarkable. A 2-cm lesion is noted in the subcortical region of the left temporal lobe. This lesion demonstrates mild enhancement. Areas of low signal on T1WI and T2WI are felt to represent foci of calcification. There is also an area of high signal on T1WI and T2WI seen inferiorly within the lesion, which probably represents an area of haemorrhage. There is a rim of surrounding oedema noted on T2WI and fluid-attenuated inversion recovery (FLAIR). What is the most likely diagnosis?
- Haemangioblastoma.
 - Desmoplastic infantile ganglioglioma (DIG).
 - Dysembryoplastic neuroepithelial tumour (DNET).
 - Pleomorphic xanthoastrocytoma (PXA).
 - Oligodendroglioma.

6. A 52-year-old man is investigated by MRI of brain for a possible transient ischaemic attack (TIA). Focal lesions of CSF signal intensity are identified adjacent to the anterior communicating cisterns. The referring neurologist suspects that these lesions are chronic lacunar infarcts. What MRI finding suggests that these are in fact prominent perivascular spaces?
- No restricted diffusion on DWI.
 - Hypointense on T1WI.
 - Hyperintense on T2WI.
 - Suppress on FLAIR.
 - Normal surrounding brain parenchyma.
7. A patient with a known diagnosis of a neurocutaneous syndrome is having a routine follow-up MRI scan. This patient is noted to have a history of right retinal calcifications. On MRI a retinal lesion is noted in the right eye, which is increased signal on T1WI. The scan shows a 2-cm lesion in the left lateral cerebellar hemisphere. This is predominantly low on T1WI and high on T2WI, but has a peripheral nodular area, which has a central signal void and demonstrates enhancement on T1WI. A further small enhancing lesion is noted in the cervical spinal cord, with an associated syrinx. The appearances are unchanged from previous imaging. Based on these findings, which neurocutaneous syndrome does this patient have?
- Neurofibromatosis type 1 (NF-1).
 - Neurofibromatosis type 2 (NF-2).
 - Tuberous sclerosis.
 - Sturge Weber syndrome.
 - Von Hippel-Lindau syndrome.
8. A 32-year-old man presents with recent onset of migraine and TIAs. He also reports some cognitive decline. Cerebral angiogram is normal. An MRI of brain reveals discrete hyperintensities in the anterior temporal poles and external capsules. What is the most likely diagnosis?
- Cerebral autosomal dominant arteriopathy with subcortical infarcts and leukoencephalopathy (CADASIL).
 - Mitochondrial myopathy, encephalopathy, lactic acidosis, and stroke (MELAS).
 - Myoclonic epilepsy with ragged red fibres (MERRF).
 - Sporadic subcortical arteriosclerotic encephalopathy (SSAE).
 - Protein S deficiency.

9. A 36-year-old patient with known AIDS is admitted to your hospital with a right-sided hemiparesis. His wife gives a history of cognitive decline, headache, and lethargy for the past few weeks, but with an acute deterioration in the last 36 hours. His CD4 counts are between 200 and 500 (category B). An MRI is carried out which shows multiple ring-enhancing lesions in the brain. These lesions are high signal on T2WI/FLAIR, but demonstrate a low intensity peripheral ring. Lesions are noted in the basal ganglia bilaterally. The cortical region and subcortical U-fibres are spared. A thallium SPECT is also carried out that shows abnormal uptake in the brain, which correlates with the areas identified on MRI. What is your primary diagnosis?

- A. Nocardia abscesses.
- B. Toxoplasmosis.
- C. Progressive multifocal leukoencephalopathy.
- D. Primary CNS lymphoma.
- E. Cerebral cryptocococcus infection.

10. A 50-year-old male patient is referred from A&E for a CT brain. He has a history of headache for 2 months and increasing clumsiness. The CT shows a lesion abutting the sphenoid in the anterior cranial fossa. It measures 4 cm in size and demonstrates heterogeneous enhancement. There is no evidence of calcification. The lesion is displacing and effacing the third ventricle, causing mild hydrocephalus in the lateral ventricles. An MRI is performed. The lesion is isointense on T1WI and T2WI, and demonstrates an enhancing dural tail and broad dural base. Again the enhancement pattern is heterogeneous. A number of flow voids are noted in the lesion. There is little peritumoural oedema noted. An MR angiogram is performed, which indicates dual supply to the lesion from the internal and external carotid artery. What lesion typically demonstrates these imaging findings?

- A. WHO 1 meningioma.
- B. WHO 3 meningioma.
- C. Haemangiopericytoma.
- D. Melanocytoma.
- E. Schwannoma.

11. A patient is referred to your neurointerventional team for embolization of a meningioma prior to surgical resection. The lesion is based on the tentorium. What is the likely feeding vessel (parent vessel is named in brackets)?

- A. Anterior meningeal artery (vertebral).
- B. Middle meningeal artery (external carotid artery (ECA)).
- C. Posterior meningeal artery (variable).
- D. Bernasconi-Casanari artery (internal carotid artery (ICA)).
- E. Dorsal meningeal artery (ICA).

12. A 7-year-old girl is brought into A&E with a history of headache of 4 hours' duration, associated with neck stiffness. The parents noted a petechial rash and are concerned about the possibility of meningitis. There is no photophobia and no other neurological signs are present. A&E have requested a CT scan to rule out raised intracranial pressure and to diagnose meningitis, whilst also commencing antibiotic therapy for presumed meningitis. The CT scan is normal. As it is a normal working day, A&E have also requested an MRI scan to diagnose meningitis. This was not carried out as the child was agitated. The following day the child develops a pyrexia and a right unilateral aspect to the headache, with decreased GCS. An MRI is carried out and demonstrates features of developing right temporal lobe empyema. Which of the following is an appropriate indication for imaging in the investigation of meningitis?
- CT to rule out raised intracranial pressure.
 - CT to diagnose meningitis.
 - MRI to diagnose meningitis.
 - MRI due to deterioration in clinical course.
 - All of these.
13. A 13-year-old boy is brought to your paediatric hospital with a recent history of headache and high fever. The child is becoming progressively drowsy and demonstrates rigidity and tremor on neurological examination. An MRI is requested. Relevant past medical history on the request form is of recent travel to Asia, history of measles as a 6-year-old and recent viral infection. The MRI scan shows increased signal on T2WI and FLAIR sequences in the hippocampal regions of the temporal lobes. There is also increased FLAIR signal in the thalamus and putamina bilaterally. Small foci of increased T1WI signal within these regions are felt to represent haemorrhage. What diagnosis would you place at the top of your differential list?
- Herpes simplex type 1 encephalitis.
 - Herpes simplex type 2 encephalitis.
 - Japanese encephalitis.
 - Varicella Zoster encephalitis.
 - Subacute sclerosing panencephalitis (SSPE).

14. An 8-year-old female patient presents to your paediatric neurology service with a history of increasing ataxia, repeated headaches, and vomiting, increasing in severity over the last 5 months. Clinical examination reveals marked cerebellar signs of past pointing and dysidiadochokinesis. An MRI is requested, which shows a solid mass in the posterior fossa measuring 2 cm in size. This mass arises in the left cerebellar hemisphere and displaces the fourth ventricle. It is of low intensity on T1WI and high signal on T2WI. There is only a small rim of surrounding oedema. The lesion demonstrates relatively homogeneous moderate enhancement. There is no evidence of subarachnoid seeding. What is the most likely diagnosis?

A. Pilocytic astrocytoma.

B. Ependymoma.

C. Medulloblastoma.

D. Metastasis.

E. Lhermitte-Duclos syndrome.

15. A 30-year-old male patient is referred from ENT for an MRI with a history of tinnitus and slight hearing loss on the left side. A lesion is noted in the left cerebellopontine angle. This extends along the nerve and expands the internal auditory canal. A separate nerve is noted to enter the anterior superior portion of the internal auditory canal. The lesion is isointense to the pons on all pulse sequences. The lesion makes an acute angle with the petrous bone. There is no evidence of a dural tail following enhancement. What is the most likely cause?

A. Meningioma.

B. Facial nerve schwannoma.

C. Vestibular nerve schwannoma.

D. Epidermoid.

E. Arachnoid cyst.

16. An MRI is carried out for your neurology service on a 30-year-old male patient. The most pertinent abnormality is of thick smooth meningeal enhancement following the dural-arachnoid around the convexity, falx, and tentorium without extension into the basal ganglia or ventricles. The referring clinician arrives to discuss the findings, but has mislaid the request form and clinical information. While he is looking for it, what do you think the most likely clinical presentation is?

A. Neck stiffness, photophobia, raised WCC, petechial rash.

B. Neck stiffness, drowsiness, with history of breast cancer.

C. Acute limb weakness on right side 3 days previously, not resolving.

D. Recent back surgery complicated by ongoing CSF leak.

E. Possible fungal meningitis in immunocompromised patient.

17. A patient is having an MRI scan carried out to investigate a possible right frontal astrocytoma, incidentally detected on CT following a head injury. The MRI features are typical of an astrocytoma, with no evidence of necrosis or callosal involvement to indicate glioblastoma multiforme (GBM). MRS has been carried out to help assess the grade of this tumour. What MRS features would indicate a high grade lesion?
- A. Elevated choline, reduced N-acetyl aspartate (NAA), choline/creatine (Cho/Cr) ratio of 1.
 B. Elevated choline, reduced NAA, Cho/Cr ratio of 2.
 C. Normal choline, elevated NAA.
 D. Reduced choline, reduced NAA, Cho/Cr ratio of 1.2.
 E. All normal, these are unaffected by tumour grade.
18. Which one of the following orbital pathologies typically arises from the intracanal compartment?
- A. Cavernous haemangioma.
 B. Adenocystic carcinoma.
 C. Rhabdomyosarcoma.
 D. Dermoid.
 E. Orbital pseudotumour.
19. A 35-year-old man presents with tinnitus and hearing loss in the right ear. Investigations include an MRI of the internal auditory meati. This demonstrates an expansile lesion in the right petrous apex, without bone destruction. The lesion is of increased signal on T1WI, increased signal on T2WI, and non-enhancing. What is the most likely diagnosis?
- A. Cholesteatoma.
 B. Petrous apex cephalocele.
 C. Mucocoele.
 D. Petrous apicitis.
 E. Cholesterol granuloma.
20. A 54-year-old lady with a history of exophthalmos undergoes a CT scan of orbits for assessment. There is spindle-shaped enlargement of extra-orbital musculature that does not involve the tendinous insertions. Which pair of muscles is most likely to be involved?
- A. Superior and inferior.
 B. Superior and medial.
 C. Superior and lateral.
 D. Inferior and medial.
 E. Inferior and lateral.
 F. Medial and lateral.

21. A 7-year-old boy presents with rapid onset right proptosis. CT shows an extraconal mass in the right orbit with irregular margins. There is evidence of intracanal and intracranial extension. On MRI, the lesion is of decreased signal on T1WI, increased signal on T2WI, and shows relatively uniform enhancement. What is the most likely diagnosis?
- Retinoblastoma.
 - Non-Hodgkin lymphoma.
 - Capillary haemangioma.
 - Ruptured dermoid cyst.
 - Rhabdomyosarcoma.
22. A 10-year-old girl presents with gradual onset proptosis in the left eye and is noted to have restricted left eye movements. An MRI scan is performed and this demonstrates a poorly circumscribed lobulated lesion that involves both the intracanal and extraconal compartments. The lesion has mixed signal intensity on T1WI, with areas of increased and decreased signal. It is mostly of increased signal on T2WI and there are areas containing a fluid-fluid level. Post contrast, there is heterogeneous enhancement. What is the most likely diagnosis?
- Venous-lymphatic malformation.
 - Orbital varix.
 - Cavernous haemangioma.
 - Capillary haemangioma.
 - Haemangiopericytoma.
23. A 20-year-old female with a history of neurofibromatosis presents with reduced visual acuity in the right eye. She subsequently has CT and MR imaging of the orbits to assess for a tumour relating to the right optic nerve. Which of the following findings on imaging would be more suggestive of the presence of an optic nerve glioma, rather than a meningioma arising from the optic nerve sheath?
- Presence of the 'tram-track' sign.
 - Presence of optic canal widening.
 - Presence of marked intense tumour enhancement.
 - Presence of calcification.
 - Presence of bony hyperostosis.

- A. Meningioma.
- B. Schwannoma.
- C. Neurofibroma.
- D. Paraganglioma.
- E. Metastasis.

26. A 45-year-old man presents with a 4-month history of worsening lower back pain radiating into the right lower extremity with weakness. An MRI scan of lumbar spine shows a 3-cm well-defined ovoid lesion eccentrically placed at the conus medullaris, the location of which is felt to be intradural and extramedullary. It is hypointense on T1WI and hyperintense on T2WI. There are flow voids and haemorrhage within the lesion. It enhances avidly post injection of contrast. Which of the following lesions fits best with the imaging findings?

- A. Proton density.
- B. STIR.
- C. T1 with fat suppression.
- D. FLAIR.
- E. T1 post gadolinium.

25. A 42-year-old woman has a CT scan of brain performed for the investigation of headache. A lesion with density similar to cerebrospinal fluid is noted at the right cerebellopontine angle. A subsequent MRI scan is performed and this shows that the lesion is well defined, of decreased signal on T1WI and increased signal on T2WI. You think the lesion is most likely an epidermoid cyst, but wish to exclude an arachnoid cyst. Which of the following further MRI sequences will be most helpful in achieving this aim?

- A. Transverse/internal auditory canal.
- B. Longitudinal/internal auditory canal.
- C. Transverse/labyrinthine.
- D. Longitudinal/labyrinthine.
- E. Transverse/mastoid.
- F. Longitudinal/mastoid.

24. A 45-year-old man has a severe head injury and is noted to have a left facial nerve palsy. Following stabilization, a subsequent HRCT scan of the temporal bone is performed. This demonstrates a fracture of the left temporal bone, involving the course of the left facial nerve. Which orientation of fracture and which segment of the facial nerve are most likely to be involved?

27. A 45-year-old woman presents with a several month history of neck pain and gradually progressive weakness and paraesthesia in the upper limbs. An MRI scan of the cervical spine is performed and this shows a well-defined central intramedullary mass in the mid-cervical spinal cord. The mass is generally slightly hyperintense on T2WI, but also has a few low signal peripheral areas. It enhances homogeneously with gadolinium. What is the most likely diagnosis?

- A. Astrocytoma.
- B. Metastasis.
- C. Haemangioblastoma.
- D. Ganglioglioma.
- E. Ependymoma.

28. A 30-year-old male patient attends A&E 30 minutes after a head injury. He has consumed alcohol. You are contacted by the A&E doctor, who requests a CT brain. At this time, which of the following is a correct indication for immediate scanning?

- A. Two episodes of vomiting.
- B. GCS 13.
- C. Loss of consciousness.
- D. Amnesia for 20 minutes before accident.
- E. Visual hallucinations.

29. A 27-year-old female patient undergoes urgent neuroimaging following loss of consciousness as a result of an RTA. CT is unremarkable. MRI reveals multiple small areas of increased signal on T2WI in the white matter near the grey-white matter junction within the frontal and temporal lobes. In the same locations, DWI reveals areas of increased signal on the B1000 image and reduced signal on the ADC map. What is the most likely diagnosis?

- A. Subarachnoid haemorrhage.
- B. Extradural haematoma.
- C. Subdural haematoma.
- D. Hypoxic brain injury.
- E. Diffuse axonal injury.

30. A 34-year-old man undergoes MRI of brain after admission for head trauma. Which of the following sequences is most sensitive for subarachnoid haemorrhage?

- A. T1WI.
- B. T1WI with fat saturation.
- C. T2WI.
- D. FLAIR.
- E. Proton density.

31. A 58-year-old patient is found at home with a reduced GCS. CT brain reveals atrophy only. MRI brain reveals hyperintensity in the tegmentum (except for the red nucleus) and hypointensity of the superior colliculus on T2WI, as well as hyperintensity in the basal ganglia. What is the most likely cause?

- A. Cocaine abuse.
- B. Methanol poisoning.
- C. Primary basal ganglia haemorrhage.
- D. Wilson's disease.
- E. Carbon monoxide poisoning.

32. A 27-year-old man suffers a head injury. A CT brain is performed. Which of the following features favours a subdural haematoma (SDH) over an extradural haematoma (EDH)?

- A. The haematoma measures 50 HU.
- B. The presence of a temporal skull fracture.
- C. The haematoma crosses the midline over the falx.
- D. The collection has a biconvex configuration.
- E. The haematoma crosses sutures.

33. A 65-year-old woman with a history of previous subarachnoid haemorrhage presents with slowly progressive cognitive decline and worsening gait. A CT brain reveals ventricular dilatation with rounded frontal horns and periventricular hypodensity. What is the most likely diagnosis?

- A. Heavy metal toxicity secondary to aneurysm clip.
- B. Parkinson's disease.
- C. Alzheimer's disease.
- D. Normal pressure hydrocephalus.
- E. Binswanger's disease.

34. A 34-year-old liver transplant recipient presents to hospital with confusion and seizures. A CT brain reveals low attenuation in the deep and subcortical white matter of the occipital and parietal lobes bilaterally. There is no abnormal enhancement post IV contrast administration. As the reporting radiologist, you advise that the clinical team first:

- A. measure blood glucose
- B. measure serum alpha-feta protein
- C. measure blood pressure
- D. send coagulation screen
- E. measure d-dimer.

35. A 34-year-old female presents with neurological symptoms suggestive of MS and is referred for an MRI of brain by the neurology team. Which of the following sequences is most useful for determining if there are plaques of differing ages (i.e. dissemination in time)?
- FLAIR.
 - T2WI.
 - Pre- and post-contrast T1WI.
 - Proton density.
 - STIR.
36. A 34-year-old woman presents with a seizure. She has a history of migraine and low mood over the preceding year, and reported occasional episodes of confusion. On examination there is slight left-sided motor weakness. An MRI of brain reveals small multifocal frontal and parietal subcortical white matter T2WI hyperintensities, and a few areas of restricted diffusion in the right cerebral hemisphere on DWI. What is the most likely diagnosis?
- Multiple sclerosis (MS).
 - SLE.
 - Small vessel ischaemia.
 - Susac syndrome.
 - Lyme disease.
37. A 73-year-old has been referred for assessment of cognitive decline. A CT brain reveals cerebral atrophy and a dementia specialist refers her for PET-CT brain. Which of the following findings is most consistent with early Alzheimer's disease?
- Diffuse reduced activity.
 - Reduced activity in the precuneus and posterior cingulate gyrus.
 - Reduced activity in the frontotemporal regions.
 - Reduced activity in the caudate and lentiform nuclei.
 - Reduced activity bilaterally in the occipital cortex.
38. A 15-year-old male presents with a history of recurrent epistaxis and nasal obstruction. MRI demonstrates a lesion centred at the sphenopalatine foramen, which is hypointense on T1WI and heterogeneously intermediate signal on T2WI. Intense lesional enhancement and multiple flow voids are noted on post-gadolinium T1WI. What is the diagnosis?
- Ludwig angina.
 - Nasopharyngeal carcinoma.
 - Inverted papilloma.
 - Juvenile angiofibroma.
 - Glossus jugulare.

42. You are reporting a CT scan of neck in a patient with a head and neck cancer. You see an enlarged necrotic jugulo-digastric lymph node on the right side and wish to describe the appropriate level of this lymph node in your report. What is the correct level?

- A. I.
- B. II.
- C. III.
- D. IV.
- E. V.
- F. VI.
- G. VII.

41. A 12-year-old male with a history of gelastic seizures is referred for MRI of the brain. Which of the following statements regarding hamartomas of the tuber cinereum is true?

- A. No change in size, shape, or signal intensity on follow-up MRI.
- B. Demonstrate homogeneous contrast enhancement.
- C. Calcification is a common finding.
- D. Hyperintense on T1WI and T2WI, and hypointense on fat suppressed sequences.
- E. Located in the sella turcica.

40. A 45-year-old female patient presents with recurrent frontal sinusitis following functional endoscopic sinus surgery (FESS). Which of the following CT findings is not commonly associated with postoperative frontal recess stenosis?

- A. Juvenile angiofibroma.
- B. Inverted papilloma.
- C. Antrochoanal polyp.
- D. Invasive fungal sinusitis.
- E. Nasal carcinoma.

39. A 50-year-old male presents with a history of intermittent epistaxis, nasal obstruction, and frontal headache. He undergoes a CT of the sinuses that demonstrates an isodense soft-tissue mass filling the right maxillary antrum with extension through the infundibulum into the nasal cavity. There is associated bony remodelling of the infundibulum. On MRI, the mass is isointense to muscle on T1WI and T2WI, and demonstrates a convoluted cerebroform pattern on enhanced T1WI. The remainder of the sinuses are unremarkable. What is the diagnosis?

43. A 4-week-old infant with a history of breech delivery is brought to the A&E department with a history of swelling in the left side of the neck and torticollis. An ultrasound of the neck demonstrates a non-tender, focal fusiform enlargement of the lower half of the left sternocleidomastoid muscle. No other abnormality is identified. What is the diagnosis?
- Fibromatosis coli.
 - Lymphoma.
 - Rhabdomyosarcoma.
 - Cystic hygroma.
 - Branchial cleft cyst.
44. A 60-year-old female presents with a history of facial pain and diplopia. Clinical examination reveals palsies of the III, IV, and VI cranial nerves. Horner's syndrome, and facial sensory loss in the distribution of the ophthalmic and maxillary divisions of the trigeminal (V) cranial nerve. Where is the causative abnormality located?
- Dorello's canal.
 - Cavernous sinus.
 - Superior orbital fissure.
 - Inferior orbital fissure.
 - Meckel's cave.
45. A 50-year-old male undergoes an MR carotid angiogram on which an incidental soft-tissue mass is noted in right parapharyngeal soft tissue. The mass displaces the right parapharyngeal space anteromedially. What is the location of the soft-tissue mass?
- Masticator space.
 - Carotid space.
 - Retropharyngeal space.
 - Mucosal space.
 - Parotid space.
46. A 55-year-old man undergoes ^{99m}Tc scintigraphy on which incidental note is made of multiple foci of increased tracer uptake in the parotid regions. Ultrasound of the parotid glands demonstrates bilateral multiple hypoechoic lesions with anechoic areas. On MRI, the lesions are of intermediate signal intensity on T1WI and intermediate signal intensity with focal areas of hyperintensity on T2WI. There is no enhancement following contrast administration. What is the likely diagnosis?
- Pleomorphic adenomas.
 - Warthin tumours.
 - Lipomas.
 - Haemangiomas.
 - Mucoepidermoid carcinomas.

47. A 60-year-old woman presents with a painless, slowly growing mass in the lateral aspect of the neck. The patient is referred for imaging with a clinical diagnosis of carotid body paraganglioma. Which of the following is a distinctive feature of carotid body paraganglioma on imaging?
- Soft-tissue mass in the carotid space.
 - Intense enhancement after IV contrast administration.
 - High signal on T2WI.
 - Splaying of the internal and external carotid arteries.
 - Low signal on T2WI.

48. A 22-year-old woman presents with upper and lower limb neurological symptoms and signs. She is subsequently discovered on MRI to have a mass in the cervical spinal cord. Which of the following features on MRI is going to point more towards a diagnosis of spinal cord astrocytoma, rather than ependymoma?

- Predominant T2WI high signal.
- Homogeneous enhancement post gadolinium.
- Short segment of cord involvement.
- Eccentrically placed lesion in the cord.
- Sharply margined lesion.

49. A 52-year-old woman presents with gradually increasing gait disturbance and lower limb sensory symptoms. An MRI of her spine is performed and this shows an anteriorly placed intradural, but extramedullary spinal mass. It is fairly markedly low signal on T1WI and T2WI, and shows only minimal patchy enhancement post administration of intravenous gadolinium. What is the most likely diagnosis?

- Neurofibroma.
- Schwannoma.
- Lymphoma.
- Metastasis.
- Meningioma.

50. You are asked to protocol an MRI scan that is specifically being performed to look for vertebral metastatic disease. The radiographer complains that you have asked for too many sequences. Which of the following sagittal sequences is likely to be least helpful for the purposes of your examination?

- STIR.
- T2 fast SE with fat saturation.
- T2 fast SE.
- T1 fast SE.
- T1 GE out of phase.

51. A 44-year-old woman presents with severe facial injuries following an RTA. CT of the facial bones demonstrates multiple maxillofacial fractures in keeping with a Le Fort configuration. Which of the following statements regarding Le Fort fractures is false?

- A. Any combination of Le Fort I, II, and III fractures can occur.
- B. Disruption of pterygoid plates from the posterior maxilla is an essential finding in Le Fort fractures.
- C. Le Fort fractures by definition refer to fractures involving the maxilla bilaterally.
- D. Craniofacial separation is noted in Le Fort III pattern.
- E. Le Fort fracture associated with a palate fracture will result in widening of the maxillary arch.

52. A 25-year-old woman is brought to the A&E department following an RTA. CT of brain and facial bones are requested for assessment of head and facial injuries. On the CT studies, incidental note is made of dense calcification of the falx cerebri, midface hypoplasia, and prognathism. Multiple cystic lesions are also noted in the mandible, which are associated with cortical expansion. Some of the lesions break through the cortex. Following contrast administration there is minimal peripheral enhancement. What is the underlying mandibular abnormality?

- A. Radicular cyst.
- B. Keratocystic odontogenic tumour.
- C. Dentigerous cyst.
- D. Stafne cyst.
- E. Ameloblastoma.

53. A 45-year-old female undergoes an MRI of the pituitary that demonstrates a kidney-shaped lesion located centrally in the pituitary fossa in the axial plane. It is hyperintense on T1WI and hypointense on T2WI. There is no enhancement following gadolinium administration and no fluid-fluid level. What is the diagnosis?

- A. Rathke cleft cyst.
- B. Craniopharyngioma.
- C. Cholesterol granuloma.
- D. Haemorrhagic adenoma.
- E. Lipoma.

- A. NF-2.
- B. Neurosarcomatous.
- C. Neurotoxoplasmosis.
- D. Tuberculous sclerosis.
- E. Multiple sclerosis.

56. A 42-year-old male patient of African-Caribbean ethnicity presents to the neurologists with a history of facial paraesthesia and slight weakness, headache, lethargy, and neck stiffness. He also has a history of mild dyspnoea. An MRI is requested, which shows left frontal leptomeningeal thickening, with an apparent dural mass noted along the falx. There is increased T2WI/FLAIR signal in the cortex adjacent to this area of meningeal disease. There is also thickening and enhancement noted of the right trigeminal and facial nerves on post-contrast T1WI. Further enhancement is also noted along the parasellar region on the left. Multiple non-enhancing high T2WI/FLAIR periventricular white matter lesions are noted. Abnormality is noted in the skull vault, where there is an expanded diploic space over the right occipital region, with associated apparent thinning of the outer table, although this is hard to define on MRI. Due to concern with regard to multifocal meningioma the patient is started on steroids to reduce the mass effect from the frontal lesion and referred to neurosurgery. A CT is non-contributory. An MRI is repeated, which shows only mild meningeal thickening. What is the most likely diagnosis?

- A. Enhancing wall.
- B. Rounded or ovoid configuration.
- C. Mass effect.
- D. Filling of retropharyngeal space from side to side.
- E. Primary infection source such as otitis media or tonsillitis.

55. A 5-year-old girl with a clinical suspicion of retropharyngeal abscess is referred for MRI of the neck. Which of the following features on MRI is useful in differentiating retropharyngeal abscess from retropharyngeal suppurative lymph node?

- A. Dermoid cyst.
- B. Lymphangioma.
- C. First branchial cleft cyst.
- D. Abscess.
- E. Second branchial cyst.

54. A 30-year-old male presents with a fluctuant swelling in the right side of the neck. On ultrasound examination, an anechoic lesion with posterior acoustic enhancement is noted along the anteromedial margin of the sternocleidomastoid muscle, posterior to the submandibular gland and superficial to the carotid artery and internal jugular vein. There is no increased surrounding vascularity on power Doppler. What is the likely diagnosis?

57. A 62-year-old man presents with tremor and incontinence. Examination reveals bradykinesia and gait ataxia. He is also noted to have a reduced mini mental state examination (MMSE) and postural hypotension. He has an MRI scan of brain as part of the diagnostic workup. On the axial T2WI a cruciform hyperintensity in the pons is noted. Which of the following is the most likely diagnosis?
- Parkinson's disease.
 - Multisystem atrophy (MSA).
 - Progressive supranuclear palsy (PSP).
 - Cryptobasal degeneration.
 - Lewy body dementia.
58. A 56-year-old man with chronic alcohol dependence presents with progressive cognitive impairment, gait disturbance, and signs of interhemispheric disconnection. An MRI scan of brain demonstrates increased T2WI signal lesions without mass effect within the corpus callosum and dorsal part of the external capsule. Which of the following is the most likely diagnosis?
- Wernicke's encephalopathy.
 - Osmotic myelinolysis.
 - Marchifava-Bignami disease.
 - Alcohol withdrawal syndrome.
 - Chronic hepatic encephalopathy.
59. A 74-year-old woman is admitted with acute left-sided hemiplegia of 2 hours onset. On assessment by the stroke team she is deemed suitable for thrombolysis and referred for CT. As part of your institution's work-up, CT perfusion (CTP) is performed following the unenhanced study. Which of the following CTP findings with regards to cerebral blood flow (CBF), cerebral blood volume (CBV) and mean transit time (MTT) are consistent with infarction?
- Decreased CBF/decreased CBV/increased MTT.
 - Decreased CBF/increased CBV/increased MTT.
 - Decreased CBF/decreased CBV/decreased MTT.
 - Increased CBF/increased CBV/decreased MTT.
 - Increased CBF/decreased CBV/decreased MTT.

60. An immunocompetent 24-year-old patient presents with an acute history of right-sided limb weakness which has rapidly progressed. The patient now also has mixed sensory symptoms and poorly controlled seizures. Basic observations and initial blood results are normal. An MRI is carried out which shows a large mass-like lesion in the right posterior frontal lobe. There is mild mass effect associated with this lesion on the adjacent parenchyma, with mild compression of the right lateral ventricle. The lesion is also noted to involve the corpus callosum and cross the midline into the left cerebral hemisphere. This lesion is bright on FLAIR imaging. On post-contrast T1WI the lesion has peripheral rim enhancement. Vascular structures are noted to pass through the lesion. There is no evidence of necrosis or haemorrhage. On DWI, the b1000 sequence reveals increased signal in the lesion. Other high T2WI lesions are noted in the cerebellum, with a further lesion in the spinal cord. What is the most likely diagnosis based on this information?

- A. MS.
- B. Glioblastoma multiforme.
- C. High-grade astrocytoma.
- D. Lymphoma.
- E. Abscess.

61. A 32-year-old woman of 38 weeks gestation presents with seizure following a headache. She is referred for CT querying venous thrombosis. Unenhanced CT brain demonstrates bilateral low attenuation change within the thalam. Given this location, where is the most likely site of thrombosis?

- A. Superior sagittal sinus.
- B. Transverse sinus.
- C. Sigmoid sinus.
- D. Straight sinus.
- E. Cavernous sinus.

62. A 36-year-old man is admitted following a seizure. Unenhanced CT demonstrates a right frontal mixed attenuation lesion, which avidly enhances post contrast. Multiple flow voids are seen on MRI of brain. What finding on catheter angiography differentiates arteriovenous malformation (AVM) from other vascular lesions of the brain?

- A. Early venous drainage.
- B. Arterial stenoses of feeder vessels.
- C. External carotid transdural supply.
- D. Dilated medullary veins (caput medusae).
- E. Dilated cortical veins.

63. You are contacted by the A&E department requesting a CT brain for a 28-year-old female presenting with headache which reached peak intensity 15 minutes after onset. The headache came on during sexual activity and is associated with vomiting. Which feature in the clinical history is most predictive of subarachnoid haemorrhage?
- Female sex.
 - Age <40 years.
 - 15 minute onset to peak intensity.
 - Onset during sexual activity.
 - Association with vomiting.
64. A 54-year-old female is admitted following a seizure. CT of the brain demonstrates a rounded, 2-cm hyperdense lesion within the right temporal lobe, which exhibits calcification. No enhancement is seen post contrast. On follow-up MRI of brain, the lesion is of mixed intensity on T1WI. The lesion has a hypointense rim on T2WI. Prominent susceptibility effect is noted on T2* GE imaging. DWI is normal and no enhancement is demonstrated on T1WI post gadolinium. Based on the imaging findings, what is the most likely diagnosis?
- AVM.
 - Haemorrhagic neoplasm.
 - Cavernous malformation (cavernoma).
 - Amyloid angiopathy.
 - Capillary telangiectasia.
65. A 42-year-old man is admitted with sudden onset headache suspicious of subarachnoid haemorrhage. There is no loss of consciousness. Unenhanced CT demonstrates blood in the cisterns around the midbrain and into the anterior part of the interhemispheric fissure. Subsequent CT angiogram (CTA) is negative. What is advised next for this patient?
- Lumbar puncture.
 - MRA.
 - Catheter angiography.
 - Repeat CTA in 1 week.
 - No further investigation necessary (perimesencephalic haemorrhage).
66. A 74-year-old man with a history of diabetes presents with a history of slurred speech and right-sided weakness, which spontaneously resolved over 1–2 hours. Initial unenhanced CT is normal. Further investigation by MRI is requested. What sequence is most sensitive for diagnosing acute ischaemia?
- T2WI.
 - FLAIR.
 - DWI.
 - GE imaging.
 - T1WI post gadolinium.

67. A 16-year-old female is referred for MRI after presenting with an increasing number of cutaneous neurofibromata. As a child she had been noted to have a café-au-lait spot on her back. What MRI finding would confirm the diagnosis of NF-1?

- A. Multiple hyperintense white matter foci on T2WI.
- B. Bilateral vestibular schwannomas.
- C. Meningioma.
- D. Optic nerve glioma.
- E. Multiple ependymomas.

68. A 16-year-old male with a history of epilepsy is investigated via MRI. Axial T2WI demonstrates a cystic space within the left frontal lobe isointense to CSF. This is causing local mass effect and there is adjacent enlargement of the left lateral ventricle. What is the most likely diagnosis?

- A. Porencephalic cyst.
- B. Arachnoid cyst.
- C. Schizencephaly.
- D. Hydranencephaly.
- E. Ependymal cyst.

69. A 32-year-old man presents with schizophrenic-like psychosis and parkinsonian-type movement disorder. There is a family history of neuropsychiatric disturbance. An initial CT is requested which demonstrates heavy bilateral, symmetric calcifications within the globus pallidus, thalami, putamen, and cerebellum. There is no enhancement post contrast. Which of the following suggests a diagnosis of Fahr disease over pseudohypoparathyroidism?

- A. Involvement of the globus pallidus.
- B. Involvement of the thalami.
- C. Involvement of the putamen.
- D. Involvement of the cerebellum.
- E. Normal calcium-phosphorus metabolism.

70. A 29-year-old female complains of increasing headache, followed by generalized seizure activity 24 hours after giving birth. She is noted to be hyperintense. MRI demonstrates bilateral parieto-occipital T2WI hyperintense cortical and subcortical lesions. ADC is elevated. Similar lesions are noted in the anterior watershed zones. What is the most likely diagnosis?

- A. Hypotensive cerebral infarction.
- B. Postpartum cerebral angiodopathy.
- C. Posterior reversible encephalopathy syndrome (PRES).
- D. Progressive multifocal leukoencephalopathy (PML).
- E. Gliomatosis cerebri.

71. A 62-year-old man is referred for MRI of brain after presenting with cognitive decline, gait apraxia, and urinary incontinence. There is a preceding history of chronic headache. Ventriculomegaly is noted on initial CT. Which of the following conventional MRI findings distinguishes aqueductal stenosis from normal pressure hydrocephalus?
- Periventricular T2WI hyperintensity.
 - Normal sulci.
 - Aqueductal flow void.
 - Funnel-shaped aqueduct.
 - Relatively normal calibre fourth ventricle.

72. A 24-year-old male boxer is admitted with concussion following a head injury. His admission CT does not demonstrate any evidence of intracranial injury, but the A&E physician asks you about a midline CSF space. You explain that this is a cavum velum interpositum. What distinguishes this CSF space from cavum septum pellucidum and cavum vergae?
- Position between the frontal horns of the lateral ventricles.
 - Posterior extension between the fornices.
 - Does not extend anterior to foramen of Monro.
 - Mildly hyperdensity to CSF in lateral ventricles.
 - Absent septum pellucidum.

73. A 42-year-old male is admitted with first presentation of a seizure. There is no significant past medical history. CT demonstrates a mass lesion within the right frontal lobe. He is further investigated via MRI, which includes MR perfusion and spectroscopy. The neurosurgical team are keen to biopsy this lesion if there is radiological suspicion of a high-grade lesion. Which of the following radiological findings is most consistent with a high grade lesion?
- Relative cerebral blood volume (rCBV) 1.5 on MR perfusion.
 - Lactate peak on MRS.
 - Elevated ADC on DWI.
 - Peritumoral hyperintensity on T2WI.
 - Nodular enhancement on T1WI post gadolinium.

74. A 54-year-old man presents with hearing loss in the left ear, which is of the sensori-neural type. He undergoes an MRI scan of the internal auditory meati and subsequently a full MRI scan of brain. A large extra-axial mass lesion is identified at the left cerebellopontine angle. Which of the following features on MR imaging will be most helpful in indicating that this is probably a large vestibular schwannoma, rather than a meningioma?
- Enhancing dura adjacent to the mass.
 - Erosion of the adjacent porus acusticus.
 - Tumour within the adjacent internal auditory meatus.
 - Intense enhancement within the mass.
 - Hyperostosis in the adjacent petrous temporal ridge.

75. A 32-year-old female is referred to neurology complaining of visual disturbance and headache. She is 4 months postpartum. On examination a bitemporal hemianopia is noted. Hormonal testing reveals hypoadrenalism and hypothyroidism. A dedicated MRI of her pituitary gland is requested. Which of the following features is suggestive of autoimmune hypophysitis over pituitary adenoma?

- A. Asymmetric pituitary enlargement.
- B. Heterogenous gadolinium enhancement.
- C. Loss of the posterior pituitary bright spot.
- D. Sphenoid sinus mucosal thickening.
- E. Age >30.

1. D. Germinoma.

The lesion is described in the pineal region, so the differential of pineal tumours should be considered. These are differentiated between germ cell tumours and pineal cell tumours.

Germiomas account for 40% of all pineal region masses and are much more frequent in males than females. They are also the most common germ cell tumour, with teratomas and chorioepithelioma having different imaging characteristics. The main differential in this case is

between pineoblastoma and germinoma, as both occur in patients of this age group and both are hyperdense on CT. Imaging features described to help differentiate are the avid enhancement,

which is more characteristic of germinomas, but can occur in either. Central calcification is seen commonly in germinomas, but is uncommon in pineoblastomas, and when it occurs is often

peripheral, giving the impression of an 'exploded' pineal gland. Subarachnoid seeding is seen in both tumours and if present CSF sampling can yield a tissue diagnosis. Pineocytomas occur in an

older age group and infrequently cause subarachnoid seeding.

Smitiotopoulos J, Rushing E, and Mena H. Pineal region masses: differential diagnosis. *Radiographics* 1992; 12(3): 577-596

Grossman R and Yousem D. *Neuroradiology: The Requisites*, 2nd edn, Mosby, 2003, pp. 156-162.

2. D. Symmetrical involvement of cerebral white matter.

Symmetrical involvement of the cerebral hemispheres or cerebellar peduncles is unusual in MS and is occasionally seen in acute disseminated encephalomyelitis (ADEM). ADEM can mimic nature of ADEM can be deduced both from the uniformity of lesion oedema and contrast enhancement in the acute phase. Lesions in ADEM resolve on follow-up, and although enhancing and non-enhancing lesions can coexist for a period, new lesions should not appear.

MS plaques are classically seen in the periventricular and juxtacortical white matter. The other options in the question are all common plaque locations. Involvement of the corpus callosum is characteristic. Other common supratentorial sites include the white matter abutting the temporal horns and trigones of the lateral ventricles. Cortical lesions are less conspicuous on MRI than white matter lesions, but their detection is improved by the inclusion of a FLAIR sequence. Juxtacortical white matter lesions are highly suggestive of MS, as lesions are not commonly seen in this region in normal ageing. Twelve per cent of patients have lesions on MRI limited to the spine without brain involvement.

Pretorius PM and Quaghebeur G. The role of MRI in the diagnosis of MS. *Clinical Radiology* 2003; 58: 434-448.

3. B. Metastasis.

The answer options give some of the classical radiological differentials for a ring-enhancing lesion in the brain: MAGIC DR (metastasis, abscess, glioblastoma multiforme, infarct, contusion, demyelinating conditions and post-radiotherapy change). The clinical history should steer the

reader toward the first two. DWI is reasonably useful at differentiating between these two (exceptions being in some fungal infections and toxoplasmosis), with necrotic metastasis having unrestricted diffusion and abscess having restricted diffusion. The appearances in this case are slightly confused by the DWI b1000 imaging showing increased signal. However, the presence of increased signal on the ADC map correctly identifies this as being T2 shine through, showing the importance of checking both sequences.

Chapman N and Nakielny R. *Aids to Radiological Differential Diagnosis*, 4th edn, Saunders, 2003, p. 433.

Grossman R and Yousem D. *Neuroradiology: The Requisites*, 2nd edn, Mosby, 2003, p. 143.

4. B. Haematoma hyperintense to grey matter on both T1WI and T2WI.

The MRI appearances of intracranial haemorrhage are determined primarily by the state of the haemoglobin (Hb), which evolves with age. This can be staged as hyperacute (first few hours), acute (1–3 days), early subacute (3–7 days), late subacute (4–7 days to 1 month), or chronic (1 month to years). Table 6.1 illustrates the sequential signal intensity changes of the evolving intracerebral haematoma.

Table 6.1 The sequential signal intensity changes of the evolving intracerebral haematoma

	Hyperacute	Acute	Early subacute	Late subacute	Chronic
State of Hb	Intracellular	Intracellular	Intracellular	Extracellular	Haemosiderin
Magnetic properties	Diamagnetic	Paramagnetic	Paramagnetic	Paramagnetic	Superparamagnetic
T1 Signal intensity	↔/↑	↔/↑	↔/↑	↔/↑	↔/↑
T2 Signal intensity	↓	↑	↑↑	↑↑	↑↑

Data from Patzel PM, Makkat S, Van Miert E, Van Goethem JW, van den Hauwe L, and De Schepper AM. Intracranial hemorrhage: principles of CT and MRI interpretation. *European Radiology* 2001; 11: 1770–1783.

5. E. Oligodendroglioma.

Prior to evaluating the imaging characteristics, the patient's demographics should be considered in this case, as in all cases of intracranial masses, as it will help limit the differential diagnosis significantly. The patient is an adult, thus making DGC and DNET unlikely. Secondly, consider the temporal lobe location. Haemangioblastomas are usually infratentorial in location, especially in the absence of a history of von Hippel–Lindau syndrome. All the other lesions are classical temporal lobe tumours. Finally, considering the imaging characteristics, both PXA and oligodendrogliomas may be entirely solid, but cysts are commonly seen in PXAs. Calcification is seen in 60–80% of oligodendrogliomas, but is rarely seen in PXAs. Similarly haemorrhage, while not typical of oligodendrogliomas, is rare in PXAs.

Grossman R and Yousem D. *Neuroradiology: The Requisites*, 2nd edn, Mosby, 2003, pp. 137–141.

6. E. Normal surrounding brain parenchyma.

Perivascular spaces (Virchow–Robin spaces) are pial lined interstitial fluid structures that

accompany penetrating arteries, but do not communicate directly with the subarachnoid space. They can occur anywhere, but typically cluster around the anterior commissure. They follow CSF signal intensity, suppress on FLAIR, and do not exhibit restricted diffusion. They can occasionally

be giant when located within the midbrain. Lacunar infarcts will also be hypointense on T1WI and hyperintense on T2WI. Restricted diffusion will be seen when acute/subacute. They are typically of increased signal on FLAIR, although will suppress if there is central encephalomalacia. A halo of surrounding high signal on T2WI and FLAIR is typical of lacunar infarction, although up to 25% of prominent perivascular spaces can also demonstrate a slight halo of increased signal. Lacunar infarcts are also more typically seen in the setting of more extensive white matter disease.

Osborn AG, Blaser SJ, Salzman KL, Katzman GL, Provenzale J, Castillo M et al. *Diagnostic Imaging: Brain*, Amirsys, 2004, 1-7: 22-25.

7. E. Von Hippel-Lindau syndrome.

This syndrome is characterized by retinal lesions variously described as being retinal angiomas, retinal haemangiomas, or retinal hamartomas. These lesions (Lindau tumours) cause retinal calcification, although this is also seen in NF-1 and tuberous sclerosis (TS) from other causes. The findings describe the classical appearance of a cerebellar haemangioblastoma. These lesions can also be entirely cystic or solid in a minority of cases. A signal void and lack of dural enhancement help differentiate this from other intracranial masses in adults. Twenty per cent of haemangioblastomas are associated with Von Hippel-Lindau syndrome and 80% of Von Hippel-Lindau syndrome patients have this tumour. The spinal finding also indicates a further haemangioblastoma in the cord. Unlike in the posterior fossa, these seldom have flow voids, but are associated with the development of a syrinx.

Leung R, Biswas S, Duncan M, and Rankin S. Imaging features of von Hippel-Lindau Disease.

Radiographics 2008; 28(1): 65-79.

Grossman R and Yousem D. *Neuroradiology: The Requisites*, 2nd edn, Mosby, 2003, pp. 456-457. Chapman S and Nakielny R. *Aids to Radiological Differential Diagnosis*, 4th edn, Saunders, 2003, pp. 450-451.

8. A. Cerebral autosomal dominant arteriopathy with subcortical infarcts and leukoencephalopathy (CADASIL).

This is a hereditary small vessel disease, which causes stroke in young adults. The genetic mutation is found on chromosome 19. Presentation can include migraine, cognitive decline, psychiatric disturbance, TIAs, and stroke, the latter usually with substantial/complete recovery after individual strokes, particularly early in the disease process.

Imaging reveals subcortical lacunar infarcts and leukoencephalopathy in young adults. The frontal lobe has the highest lesion load, followed by the temporal lobe and insula. Anterior temporal pole and external capsule lesions have higher sensitivity and specificity for CADASIL. The cerebral cortex is usually spared. MRI is the investigation of choice; CT will reveal only areas of hypodensity and angiography is normal.

sSAE is associated with hypertension and results in multiple lacunar infarcts in the lenticular nuclei, pons, internal capsule, and caudate nuclei. MELAS and MERRF are mitochondrial disorders. MELAS results in bilateral multiple cortical and subcortical hyperintense lesions on FLAIR images; MERRF has a propensity for the basal ganglia and caudate nuclei, and watershed ischaemic/infarcts are common. Hypercoagulable states such as protein S deficiency result in cortical and lacunar infarcts of various sizes, but the cerebral angiogram is abnormal.

Osborn AG, Blaser SJ, Salzman KL, Katzman GL, Provenzale J, Hedlund GL et al. *Diagnostic Imaging: Brain*, Amirsys, 2004, 1-4: 62-65.

9. B. Toxoplasmosis.

This is the most common intracranial opportunistic infection in AIDS patients and the most common cause of intracranial mass lesions in this population, with lymphoma second and cryptococcus third. Differentiating toxoplasmosis from lymphoma has been the subject of much debate in the literature and ultimately there is no definitive means of differentiating them on imaging alone. As described to toxoplasmosis causes multiple ring-enhancing lesions and often affects the basal ganglia. Lymphoma tends to involve the subependymal regions and can cause leptomeningeal enhancement. Lymphoma can cause encasement of the ventricle, which is not seen with toxoplasmosis. Toxoplasmosis tends to be higher intensity on T2WI/FLAIR than lymphoma.

PET and thallium SPECT have also been reported to show abnormal uptake in lymphoma, but not toxoplasmosis, although exceptions exist. Response to anti-toxoplasma treatment is often used as a clinical differentiator.

Cryptococcus classically causes dilatation of Virchow–Robin spaces. PML is a demyelinating condition secondary to JC virus of oligodendrocytes and is differentiated from other HIV-related demyelinating conditions by affecting the subcortical U fibres.

Offiah C and Turnbull I. The imaging appearances of intracranial CNS infections in adult HIV and AIDS patients. *Clinical Radiology* 2006; 61: 393–401.

Burger J. Mass lesions of the brain in AIDS: the dilemmas of distinguishing toxoplasmosis from primary CNS lymphoma. *American Journal of Neurology* 2003; 24(4): 554–555.

Grossman R and Yousem D. *Neuroradiology: The Requisites*, 2nd edn, Mosby, 2003, p. 297.

10. C. Haemangiopericytoma.

The imaging findings clearly describe an extra-axial tumour. These are classed as either lesions of meningeal origin or tumours of neurogenic origin. The broad dural base and dural tail indicates that this is a tumour of meningeal origin. Meningioma is the most common of these tumours, but the imaging characteristics are not typical. World Health Organization (WHO) 1 and 2 meningiomas demonstrate uniform enhancement, although haemorrhage into meningiomas is recognized. WHO 3 meningiomas (malignant meningiomas) are indicated on imaging when there is invasion of the adjacent parenchyma, which is not described. Otherwise the diagnosis of malignant meningioma is made by an aggressive pattern of growth on serial imaging and biopsy. The dual arterial supply is also atypical. While meningiomas can have dual supply, they more typically derive their arterial supply from the external carotid (via the meningeal artery). Melanocytomas are suggested on imaging by increased signal on T1WI and are more commonly infratentorial. Without this the diagnosis is again reached most commonly following biopsy. All the features described are typical of haemangiopericytoma.

Sibata N, Butt S, and Connor S. Imaging features of central nervous system haemangiopericytomas. *European Radiology* 2007; 17: 1685–1693.

Grossman R and Yousem D. *Neuroradiology: The Requisites*, 2nd edn, Mosby, 2003, 99–105.

11. D. Bernasconi–Casasari artery (ICA).

The majority of meningiomas occur in the parafalcine region, along the convexity or around the sphenoid. These all derive their supply from the ECA, although parafalcine meningiomas can also receive supply from a branch of the ophthalmic artery. Tentorial or cerebellopontine angle (CPA) tumours are classically fed by the Bernasconi–Casasari artery, a branch of the meningeal trunk of the ICA. Lesions around the foramen magnum, clivus, and posterior fossa are fed by branches of the vertebral artery (anterior and posterior meningeal) and meningeal trunk of the ICA.

Grossman R and Yousem D. *Neuroradiology: The Requisites*, 2nd edn, Mosby, 2003, p. 104.

12. D. MRI due to deterioration in clinical course. In the absence of clinical features of raised intracranial pressure a CT is not necessarily indicated prior to lumbar puncture to exclude raised intracranial pressure. CT is also insensitive at diagnosing meningitis, being normal in most uncomplicated cases. MRI is also negative in 50% of cases of uncomplicated meningitis. The value of imaging is in the detection of complications of meningitis, including hydrocephalus, abscess, cerebritis, venous thrombosis, and infarction. Hughes D, Raghavan A, Mordekar S, Griffiths R, and Connolly D. Role of imaging in the diagnosis of acute bacterial meningitis and its complications. *Postgraduate Medical Journal* 2010; 86(1018): 478–485.

13. C. Japanese encephalitis.

Japanese encephalitis and herpes simplex virus (HSV) encephalitis both present with similar acute and rapidly progressive neurological symptoms. The key differentiator is involvement of the basal ganglia, which is typical in Japanese encephalitis but rare in HSV. Both commonly involve the hippocampi, this being the classical appearance of HSV encephalitis. HSV type 1 is the subtype that affects adult and older children. HSV type 2 causes neonatal and *in utero* infection. Herpes varicella zoster virus (VZV) infection can be seen in immunocompromised children, but in the immunocompetent population is more typically seen in elderly patients, often, but not exclusively, in the presence of cutaneous shingles. It causes a vasculitis, which can be seen angiographically and causes bilateral increased T2VW/FLAIR foci and gyriiform enhancement in the distribution of the vasculitis. SSPE presents with a more protracted history of neurological decline.

Andrula C. Cranial viral infections in the adult. *European Radiology* 2004; 14: E132–E144. Grossman R and Yousem D. *Neuroradiology: The Requisites*, 2nd edn, Mosby, 2003, 288–304.

14. A. Pilocytic astrocytoma.

This question deals with the classical neurological differential diagnosis of a posterior fossa mass in a child. While there are many causes, pilocytic astrocytoma and medulloblastoma account for over 60% of all childhood posterior fossa masses. Pilocytic astrocytomas have a classical appearance of being cystic lesions with an avidly enhancing mural nodule. However, 30% of pilocytic astrocytomas are solid tumours. In differentiating them from medulloblastomas, pilocytic astrocytomas often arise more peripherally and displace the fourth ventricle, whereas medulloblastomas usually arise centrally from the vermis. Subarachnoid seeding is seen in up to 50% of cases of medulloblastoma. Ependymomas are also included in the differential. As these arise from the ependyma lining the ventricle, they tend to be centred on the fourth ventricle in children. Metastases are the most common cause of a posterior fossa mass in adults, but are less common in children.

Brant W and Helms C. *Fundamentals of Diagnostic Radiology*, Lippincott Williams & Wilkins, 2006, pp. 135–142.

15. C. Vestibular nerve schwannoma.

Even in the absence of the imaging findings this would be a reasonable bet as it accounts for 75% of CPA tumours. However, assessment of the imaging characteristics increases the likelihood of this diagnosis. The second most common cause of CPA tumour is meningioma (10%). Differentiating features are lack of a dural tail, acute angle with the petrous bone (seen in schwannomas, less commonly with meningiomas, which make an obtuse angle), and, most importantly, expansion of the internal auditory canal (IAC). Facial nerve schwannomas can appear in the same site and appear identical, but they only constitute 4% of lesions in this site and as such would not be the most likely cause. The facial nerve lies in the antero-superior portion of the IAC, although it cannot usually be separated from the mass in the IAC on imaging.

Grossman R and Yousem D. *Neuroradiology: The Requisites*, 2nd edn, Mosby, 2003, pp. 105–108.

16. D. Recent back surgery complicated by ongoing CSF leak.

The key feature is the pattern of meningeal enhancement. It is important to recognize that the imaging findings describe pachymeningeal, not leptomeningeal, enhancement and as such the causes of leptomeningeal enhancement (bacterial or fungal meningitis) can be discounted. Similarly a recent stroke can cause gyriiform enhancement, not pachymeningeal enhancement. Breast cancer is the most common malignancy to cause pachymeningeal enhancement, but this would usually be more nodular than smooth. CSF leak or any cause of intracranial hypotension will be associated with smooth pachymeningeal thickening, primarily over the convexities and falx. This enhances, not because of any inflammatory process, but because this part of the meninges has no blood-brain barrier, unlike the leptomeninges.

Smirniotopoulos J, Murphy F, Rushing E, Rees J, and Schroeder J. Patterns of contrast enhancement in the brain and meninges. *Radiographics* 2007; 27: 525–551.

17. B. Elevated choline, reduced NAA, Cho/Cr ratio of 2.

NAA is thought to be a marker of neuronal integrity, choline indicates cell turnover, and creatine indicates cell metabolism. Lactate is not detectable in normal brain spectra but is elevated in inflammation, infarction, and some neoplasms. Most brain conditions, whether neoplastic, vascular, or demyelinating, are associated with a reduction in NAA. A notable exception is Canavan's disease, which causes a rise in NAA. Choline is elevated in many disorders, but is markedly increased in high-grade neoplasms. It has been reported that the ratio of choline to creatine can be used to help grade tumours, with a ratio over 1.5 indicating high grade in the majority of cases. A reduced choline and NAA in an area of tumour can indicate necrosis.

Soares D and Law M. Magnetic resonance spectroscopy of the brain: review of metabolites and clinical applications. *Clinical Radiology* 2009; 64(1): 12–21.

Fayed N, Davila J, Medrano J, and Olmos S. Malignancy assessment of brain tumours with magnetic resonance spectroscopy and dynamic susceptibility contrast MRI. *European Journal of Radiology* 2008; 67(3): 427–433.

18. A. Cavernous haemangioma.

The orbital compartments are split up into extracanal, canal, intracanal, and globe. The extracanal compartment consists of fat, lacrimal gland, and bony orbit. Pathology in this region includes infection, neurofibroma, adenocarcinoma, mucocystic adenoid and adenoid cystic carcinoma, neoplasia of bone, and lymphoma.

Conal pathology (muscle) includes rhabdomyosarcoma, thyroid eye disease, and idiopathic orbital inflammation (pseudotumour).

The intracanal compartment consists of fat, lymph nodes, vessels, nerves, and the optic nerve sheath complex. Pathology in this region includes venolymphatic malformation, haemangioma, arteriovenous malformation, optic nerve meningioma/glioma, and lymphoma.

Pathology in the globe includes retinoblastoma, metastasis, and melanoma.

288–307.

Aviv RI and Mitzkeil K. Orbital imaging Part 2. Intraorbital pathology. *Clinical Radiology* 2005; 60:

19. E. Cholesterol granuloma.

The findings described are typical of cholesterol granuloma. A critical distinction is between this and a petrous carotid artery aneurysm, which may show similar features of increased T1WI signal. However, the presence of flow void, lesion centred on the carotid canal, and additional complex areas of signal due to blood products of varying ages might be expected in an aneurysm.

A petrous apex cephalocele is an area of fluid signal (hypointense T1WI, hyperintense T2WI) adjacent to the petrous apex that is in communication with Meckel's cave.

A mucocoele of the petrous apex may cause benign bony expansion and is typically of decreased signal on T1WI and increased signal on T2WI, and is non-enhancing. A cholesteatoma may have similar T1WI and T2WI signal characteristics, but these entities may be differentiated by DWI. On DWI, cholesteatoma is typically of increased signal, whereas a mucocoele is of decreased signal. Petrous apicitis is an aggressive process that typically enhances with gadolinium and is secondary to infection. There may be an accompanying history of infection, middle ear disease, diabetes, or immunocompromise.

Connor SEJ, Leung R, and Natas S. Imaging of the petrous apex: a pictorial review. *British Journal of Radiology* 2008; 81: 427–435.

20. D. Inferior and medial.

The question refers to Graves ophthalmopathy, where enlargement of the extraocular muscles is observed, with sparing of the tendinous insertions. This is in distinction to idiopathic orbital inflammatory syndrome, where the muscle swelling typically involves the tendinous insertions. In Graves ophthalmopathy, the extra-orbital muscles are involved with decreasing frequency as follows: inferior, medial, superior and lateral recti.

LeBedis CA and Sakai O. Nontraumatic orbital conditions: diagnosis with CT and MR imaging in the emergent setting. *Radiographics* 2008; 28: 1741–1753.

21. E. Rhabdomyosarcoma.

The clinical and radiological features described are typical of rhabdomyosarcoma. It usually presents in the first decade of life with a rapidly growing mass causing proptosis. The globe is often distorted and displaced, but rarely invaded. The lesion is aggressive and there may be extension into the sinuses or intracranial compartment, and bony destruction can occur. NHL is usually found in older adults, but it can occur in older children or adolescents. Unlike rhabdomyosarcoma, NHL commonly causes lacrimal gland involvement, may be hypointense on T2WI, and encases rather than distorts the globe.

Capillary haemangioma typically presents in the first few months of life. They have a proliferative phase for approximately 12 months following diagnosis and then are stable, before gradually involuting over a period of years. These lesions show rapid and persistent enhancement on CT and MRI. On unenhanced MRI, it is typically iso- to hyperintense relative to muscle on T1WI and moderately hyperintense on T2WI, with flow voids at the periphery of or within the tumour. A ruptured dermoid cyst can mimic a rhabdomyosarcoma both clinically and radiologically, but one might expect to see calcification or fatty or cystic components in the native lesion. Retinoblastoma is an intraorbital lesion.

Chung EM, Smitiotopoulos JG, Specht CS, Schroeder JW, and Cube R. Pediatric orbit tumors and tumourlike lesions: nonosseous lesions of the extraocular orbit. *Radiographics* 2007; 27: 1777–1799.

22. A. Venous-lymphatic malformation.

Venous-lymphatic malformation (previously known as a lymphangioma) typically has a presentation in childhood. MRI is the modality of choice for diagnosis, as fluid–fluid levels are almost pathognomonic of this condition and these represent areas of haemorrhage of varying ages. The MRI findings are as those described and there are typically no large feeding vessels or flow voids. The lesion is predominantly extracranial, but can insinuate into the intracranial compartment. Capillary haemangioma also presents in childhood, but may be apparent clinically and on MRI there are not typically fluid–fluid levels, but there may be flow voids within the lesion from prominent vessels. Also, enhancement is usually more rapid and persistent in capillary haemangioma than in venous-lymphatic malformation.

Orbital varices usually present in young adults and on imaging have the appearance of dilated, tortuous vessels.

Cavernous haemangioma typically presents in adulthood. They are usually well-circumscribed and most often occur in the lateral aspect of the retrobulbar intracanal space. On CT, they are slightly hypodense prior to contrast and may contain phleboliths. On MRI, they are isointense to muscle on T1WI and hyperintense on T2WI. They show progressive enhancement on multiphase dynamic imaging.

Haemangiopericytomas are rare vascular tumours that are more often seen in adults than children. Large lesions may show bony erosion and they do not typically have fluid–fluid levels on CT or MRI.

Smoker WRK, Gentry LR, Yee NK, Reede DL, and Nared JA. Vascular lesions of the orbit: more than meets the eye. *Radiographics* 2008; 28: 185–204.

23. B. Presence of optic canal widening.

The presence of a widened optic canal occurs in up to 90% of cases of optic nerve glioma. While it can also occur in meningioma, it is more common in glioma and some cases of meningioma may even have a narrowed canal secondary to bony hyperostosis.

The 'tram-track' sign is typically associated with meningioma and refers to the more avidly enhancing meningioma surrounding the non-enhancing optic nerve on axial CT and MRI imaging of the orbit. Although both meningioma and glioma enhance following intravenous contrast, it is meningioma that is more typically associated with marked intense enhancement.

Calcification and bony hyperostosis are features associated with meningioma. Calcification is rare in gliomas, unless they have previously undergone radiotherapy.

Goh PS, Gi MT, Charlton A, Tan C, Gangadharan Sundar JK, and Amirth S. Review of orbital imaging. *European Journal of Radiology* 2008; 66: 387–395.

Aviv RI and Mitzel K. Orbital imaging Part 2. Intraorbital pathology. *Clinical Radiology* 2005; 60: 288–307.

24. C. Transverse/labyrinthine.

Transverse temporal bone fractures are more commonly associated with facial nerve paralysis (approximately up to 50%) than longitudinal temporal bone fractures (approximately up to 20%). The labyrinthine segment is the most likely segment of the facial nerve to be associated with facial paralysis.

Jager L and Reiser M. CT and MR imaging of the normal and pathologic conditions of the facial nerve. *European Journal of Radiology* 2001; 40: 133–146.

25. D. FLAIR.

On a FLAIR sequence, epidermoid cysts can be differentiated from arachnoid cysts because the former show mixed iso- to hyperintense signal, but with poor demarcation, while the signal of the latter is suppressed, like the signal of CSF.

DWI offers a finding specific for extra-axial epidermoid cysts by showing very high signal. Restricted ADC compared to CSF, almost comparable to that of the brain and T2 shine-through effect, both play an important role in the high signal intensity of epidermoid cyst at DWI. This can therefore be useful in helping to distinguish them from arachnoid cysts.

Bonneville F, Savatovsky J, and Chiras J. Imaging of cerebellopontine angle lesions: an update. Part 2: Intra-axial lesions, skull base lesions that may invade the CPA region, and non-enhancing extra-axial lesions. *European Radiology* 2007; 17: 2908–2920.

26. D. Paraganglioma.

Paragangliomas are rare intradural extramedullary tumours that are usually benign and have imaging characteristics as those described. Schwannomas, neurofibromas, and meningiomas are much more common, but do not typically contain vascular flow voids or areas of haemorrhage. Meningiomas may have a dural tail or foci of calcification. Schwannomas and neurofibromas can be difficult to distinguish on imaging. They are typically isointense on T1WI and markedly hyperintense on T2WI. Enhancement may be intense and homogeneous or peripheral. Neurofibromas tend to encase, rather than displace, nerve roots.

Leptomeningeal metastases present with three different imaging patterns:

- 1) Diffuse, thin enhancing coating of the surface of the spinal cord and nerve roots.
- 2) Multiple small enhancing nodules on the surface of the cord and nerve roots.
- 3) A single mass in the lowest part of the thecal sac.

Abul-Kasim K, Thurmer MM, McKeever P, and Sundgren PC. Intradural spinal tumors: current classification and MRI features. *Neuroradiology* 2008; 50: 301–314.

27. E. Ependymoma.

Ependymoma is the most common intramedullary neoplasm in adults. It tends to be centrally located within the cord, unlike astrocytoma, which can be eccentric. Astrocytoma can have a longer segment of cord involvement than ependymoma and may have a more infiltrative margin. The peripheral low signal areas seen on T2WI in ependymoma are related to haemosiderin deposition from prior haemorrhage.

Haemangioblastoma is more often seen in the dorsal cord than the cervical cord and is typically a small well-defined lesion. It may have an associated cord cyst or syrinx. Flow voids may be seen within the lesion, from dilated vascular channels.

Ganglioglioma is a very rare, slow-growing tumour of low malignant potential. The imaging appearance is non-specific, but there are some findings that may suggest the diagnosis. Compared with other spinal cord tumours, gangliogliomas are more likely to involve long segments of the cord (greater than four levels, up to the whole cord), to be associated with bone erosion or scalloping, to have tumoral cysts, and to have areas of mixed high signal on precontrast T1WI.

Intramedullary metastasis represents less than 5% of intramedullary lesions. They usually occur in the setting of advanced malignant disease, typically from a lung or breast primary. The spinal cord oedema can seem out of keeping with the small size of the metastatic lesion.

Smith JK, and Castillo M. Imaging of spinal and spinal cord tumors. *Seminars in Roentgenology* 2006; 41: 274–293.

28. A. Two episodes of vomiting.

Almost anything will buy you a CT brain these days, but surprisingly, the GCS must be less than 13 in the A&E department within 2 hours of the injury under NICE guidelines to warrant one. After 2 hours have passed, a GCS of anything less than normal is an indication for scanning. Other factors which require a CT within 1 hour are suspected open or depressed skull fracture, sign of fracture at skull base, post-traumatic seizure, focal neurological deficit and amnesia, or loss of consciousness and coagulopathy. Additional factors which necessitate a CT brain within 8 hours are amnesia of events for greater than 30 minutes before impact, and if there is any amnesia or loss of consciousness and the patient is older than 65/dangerous mechanism of injury. Note that, perversely, even if the scan can be delayed but be performed within 8 hours, the guidelines state it should be requested immediately. Prepare to be awoken from your sleep!

NICE Guideline on Head Injury: triage, assessment, investigation and early management of head injury in infants, children and adults. September 2007. Quick reference guide. Available online at: <http://www.nice.org.uk/nicemedia/live/11836/36257/36257.pdf>.

29. E. Diffuse axonal injury (DAI).

CT is initially often normal (up to 80% of cases) in DAI. If positive, it may reveal small low attenuation foci (oedema) or high attenuation foci of petechial haemorrhage. The grey/white matter interface of the frontotemporal lobes, corpus callosum (especially the splenium), and brainstem are the most commonly involved sites in DAI. MRI is much more sensitive and is the investigation of choice.

The signal on MRI depends on the age of the lesion and whether haemorrhage is present, but classically hyperintense foci on T2WI sequences are seen acutely. In the more chronic phase, the lesions may only be detected as hypointense foci at characteristic locations on GE sequences; this appearance may remain for years. DWI reveals hyperintense foci of restricted diffusion on B1000 images, with corresponding low signal on the ADC map. The findings on DWI are easily distinguishable from extracranial haematoma/subarachnoid haemorrhage/haematoma/generalized oedema, which are discussed in other questions in this chapter.

Osborn AG, Blaser SI, Salzman KL, Katzman GL, Provenzale J, Hedlund GL et al. *Diagnostic Imaging: Brain*, Amirsys, 2004, 1-2: 30-33.

30. D. FLAIR.

Although CT is generally used for investigating acute subarachnoid haemorrhage (SAH), FLAIR sequence on MRI has been suggested as being as sensitive as or more sensitive than CT. It is particularly useful in regions where CT may be limited due to beam hardening artefacts or if there is a very small amount of blood. Acute SAH appears as high intensity on FLAIR within the cisterns and sulci. Subacute SAH may be better appreciated on MRI because of its high signal intensity when the blood is isointense to CSF on CT. SAH differs from intra-parenchymal haemorrhage in that the mix of blood with high-oxygen tension CSF delays generation of paramagnetic deoxyhaemoglobin, and oxyhaemoglobin remains present longer than in intra-parenchymal haemorrhage. This contributes to continued T2 prolongation. Beware that there are other pathological (meningiomas, leptomeningeal metastases, acute stroke, fat-containing tumour/dermoid rupture) and benign (artefact, supplemental oxygenation) causes of FLAIR hyperintensity in the subarachnoid space. Chronic haemorrhage from SAH is best detected on GE sequences, resulting in marked subarachnoid low signal (the blooming of superficial siderosis).

Stuckey SL, Goh TD, Heffernan T, and Rowan D. Hyperintensity in the subarachnoid space on FLAIR MRI. *American Journal of Roentgenology* 2007; 189: 913-921.

31. D. Wilson's disease.

Hyperintensity in the tegmentum (except for the red nucleus) and hypointensity of the superior colliculus are described as the 'face of the giant panda sign' and are seen in axial T2WI sections of the midbrain in Wilson's disease. A 'double panda sign' has also been described, with a second 'panda cub face' in the pons. Abnormal signal can also be seen in the basal ganglia and thalamus in Wilson's disease (putamen most commonly). The signal abnormalities are due to copper deposition. Signal is generally reduced on T1WI sequences, although it may be increased due to the paramagnetic effects of copper and also due to the hepatic component of Wilson's disease (a portocaval shunt can produce this latter finding). Signal is generally increased on T2WI sequences but it can be of mixed or reduced intensity. Similarly carbon monoxide poisoning and methanol poisoning can cause increased or reduced signal on T1WI. Methanol poisoning typically causes abnormal signal in the putamen, with haemorrhagic necrosis being more typical, whereas carbon

monoxide poisoning typically affects the globus pallidus. The latter would be expected to cause low attenuation in the basal ganglia on CT.

The findings on CT exclude basal ganglia haemorrhage. Amphetamine and cocaine abuse can cause high T2WI signal in the basal ganglia due to small areas of infarction, but are not associated with the midbrain changes.

Jacobs DA, Markowitz CE, Liebeskind DS, and Galetta SL. The 'double panda sign' in Wilson's disease. *Neurology* 2003; 61: 969.

32. E. The haematoma crosses sutures.

An SDH will cross suture lines and may extend over the whole cerebral hemisphere: an EDH will not. Only an EDH can cross the midline, and this usually occurs at the vertex in the setting of a venous EDH. EDHs are more usually arterial bleeds and associated with temporal skull fractures, which disrupt the adjacent middle meningeal artery. The latter are typically biconvex; SDHs are typically lentiform in shape. Both measure 50–60 HU if acute. Chronic SDHs may be iso- or hypodense to brain, although anaemia or clotting disorders can produce a similar appearance. EDH is a neurosurgical emergency more so than SDH because of the potential lucid period followed by sudden deterioration as arterial bleeding continues after having stripped the dura from the inner table of the skull.

33. D. Normal pressure hydrocephalus.

Barr RM, Gean AD, and Tuong HL. Craniofacial trauma. In: Brant WE and Helms CA (eds). *Fundamentals of Diagnostic Radiology*, 3rd edn, Lippincott, Williams & Wilkins, 2007, pp. 57–59.

Fifty per cent of cases of normal pressure hydrocephalus (NPH) are idiopathic, while 50% have a cause, e.g. meningitis, neurosurgery, head trauma, or as in the current vignette, previous subarachnoid haemorrhage. The imaging reveals dilated ventricles with rounded frontal horns, which are enlarged out of proportion to the degree of sulcal enlargement (as one would see in cerebral atrophy). On CT there may be periventricular low attenuation in the frontal and occipital regions, representing transependymal CSF flow. The MRI equivalent is periventricular high signal and there are other MRI findings, including upward bowing of the corpus callosum and the aqueductal flow void sign (reflecting increased CSF velocity through the cerebral aqueduct). The bradykinesia and gait apraxia of NPH may mimic Parkinson's disease, although there is typically no associated tremor. Binswanger's disease (also known as subcortical arteriosclerotic encephalopathy) is a continuous, irreversible ischaemic degeneration of periventricular and deep white matter. MRI reveals extensive periventricular and deep white matter hyperintensities, which reflect microinfarctions and demyelination, and enlarged ventricles.

Hathout GM. *Clinical Neuroradiology: A case based approach*, Cambridge University Press, 2009, p. 106.

Osborn AG, Blaser SI, Salzman KL, Katzman GL, Provenzale J, Hedlund GL et al. *Diagnostic Imaging: Brain*, Amirsys, 2004, II-1: 24–27.

34. C. Measure blood pressure

The CT findings are consistent with PRES. This is a usually reversible neurological syndrome with a variety of presenting symptoms ranging from altered mental status to seizures, headache, and loss of vision. Common causes include hypertension, eclampsia and pre-eclampsia, immunosuppressive medications such as cyclosporine, various antineoplastic agents (including interferon), SLE, and various causes of renal failure. Hypertension is common in PRES, but may be mild and is not universally present, especially in the setting of immunosuppression. However, in the vignette given, hypertension is a possible cause and should be sought. Cyclosporin or

tacrolimus might be causes; the former is thought to result in PRES both via a direct neurotoxic effect and by causing hypertension.

The condition is not always reversible and may result in haemorrhagic infarcts. The classic MRI finding is of hyperintensity on FLAIR in the parieto-occipital and posterior frontal cortical and subcortical white matter. Less commonly the brainstem, basal ganglia, and cerebellum are involved. Atypical imaging appearances include contrast enhancement, haemorrhage, and restricted diffusion on MRI. Abnormalities can often be seen on CT, as described in the vignette. McKinney AM, Short J, Truwit CL, McKinney ZJ, Kozak OS, SantaCruz KS et al. Posterior reversible encephalopathy syndrome: incidence of atypical regions of involvement and imaging findings. *American Journal of Roentgenology* 2007; 189: 904–912.

35. C. Pre- and post-contrast T1WI.

MS plaques are generally most conspicuous on FLAIR sequences. However, if there are enhancing and non-enhancing plaques on T1WI post-contrast, this indicates plaques of differing ages, i.e. dissemination in time. While this is not diagnostic of MS (imaging alone never is), it is very suggestive.

Proton density sequences are useful, but not quite as useful as FLAIR sequences, in showing periventricular lesions. T2WI sequences are superior to FLAIR sequences when it comes to detection of lesions in the posterior fossa and spinal cord. T2W STIR is probably superior to standard T2WI sequences in detecting spinal cord lesions, but is not routinely used. STIR sequences or fat suppression are useful when imaging the optic nerves, as contrast between lesions and the surrounding orbital fat is increased.

Pretorius PM and Quaghebeur G. The role of MRI in the diagnosis of MS. *Clinical Radiology* 2003; 58: 434–448.

36. B. SLE.

The combination of white matter hyperintensities and focal infarcts (indicated by the areas of restricted diffusion) in combination with established neurology and neuropsychiatric symptoms, in a woman of child-bearing age, strongly suggests the diagnosis of cerebral lupus. SLE is an autoimmune disorder that affects many organ systems, including the CNS. Clinical presentation can include migraine, seizures, stroke, chorea, psychosis, mood disorder, acute confusional state, cognitive dysfunction, transverse myelopathy, cranial neuropathies, and aseptic meningitis. The CNS pathology includes vasculitis, dural venous sinus thrombosis, cerebritis, intracranial haemorrhage, infarction, and infection. Infarction can occur as a result of direct thrombosis as well as embolism from Libman–Sacks endocarditis. Diffuse neuropsychiatric symptoms are attributed to direct neuronal damage mediated by antibodies.

The most common imaging finding is small multifocal T2WI or FLAIR hyperintense white matter lesions. Focal infarcts and grey matter lesions may also be seen, as well as diffuse steroid responsive subcortical lesions. Acute lesions may enhance. MR angiography and venography may show thrombotic lesions of vessels and dural venous sinus thrombosis, respectively. When a patient with SLE presents with an acute neurological deterioration, it is crucial to image them promptly: initially with unenhanced CT to exclude haemorrhage and then with MRI (including post-contrast sequences) to evaluate for stroke or abscess. Note that a negative brain MRI cannot exclude cerebral lupus. Treatment consists of immunosuppression, with anticoagulation for thrombotic events.

Stroke is atypical for MS. Small vessel ischaemia should not occur in such a young age without an underlying cause and is not a satisfactory diagnosis. Susac syndrome is a triad of encephalopathy, branch retinal artery occlusions, and hearing loss. It is a microangiopathy of unknown aetiology.

and results in multiple T2WI hyperintense deep white matter and corpus callosum lesions. Lyme disease results in T2WI hyperintense periventricular white matter lesions, which may enhance, and it may resemble ADEM or MS.

Lalani TA, Kanne JP, Hatfield GA, and Chen P. Imaging findings in systemic lupus erythematosus. *Radiographics* 2004; 24: 1069–1086.

Osborn AG, Blaser SI, Salzman KL, Katzman GL, Provenzale J, Hedlund GL et al. *Diagnostic Imaging: Brain*. Amirsys, 2004; 1-4: 54–57.

37. B. Reduced activity in the precuneus and posterior cingulate gyrus.

FDG-PET-CT has been shown to have a sensitivity and specificity of 93% for mild to moderate Alzheimer's disease. The technique has been shown to provide important prognostic information so that a negative PET-CT scan is indicative of unlikely progression of cognitive impairment for a mean follow-up of 3 years in those patients who initially present with cognitive symptoms of dementia. The more specific findings on PET-CT in Alzheimer's disease are early reduced activity in the precuneus/posterior cingulate gyrus and the superior, middle, and inferior temporal lobe gyri, with relative sparing of the primary sensorimotor and visual cortex, and sparing of the striatum, thalamus, and cerebellum.

Diffuse reduced activity of the cortical/subcortical regions and cerebellum is more typical of fronto-temporal dementia. Reduced activity in the fronto-temporal regions is more consistent with multi-infarct dementia. Reduced activity in the occipital cortex reflects the visual problems encountered in Lewy body dementia. Reduced activity in the caudate and lentiform nuclei is more typical of Huntington's chorea.

Silverman DH and Thompson PM. Structural and functional neuroimaging: focussing on mild cognitive impairment. *Applied Neurology* 2006; Feb: 10–24.

38. D. Juvenile angiofibroma.

Juvenile angiofibromas are benign but locally aggressive tumours with high vascularity. They typically occur in adolescent boys and present with recurrent epistaxis and nasal obstruction. They are centred within the sphenopalatine foramen and involve the pterygopalatine fossa, producing a bowed appearance of the posterior wall of maxillary sinus and widening of pterygopalatine fossa, inferior orbital, and pterygomaxillary fissures. Osseous erosion is commonly seen.

The specific differentiating feature on MRI is the presence of multiple flow voids on T2WI and enhanced T1WI.

Momeni A, Roberts C, and Chew F. Imaging of chronic and exotic sinonasal disease: self-

assessment module. *American Journal of Roentgenology* 2007; 189: S46–S48.

Ludwig B, Foster B, Saito N, Nadgir RN, Castro-Aragon I, and Sakai O. Diagnostic imaging in nontraumatic pediatric head and neck emergencies. *Radiographics* 2010; 30: 781–799.

39. B. Inverted papilloma.

Inverted papillomas are uncommon benign epithelial neoplasms with significant malignant potential. They arise from the lateral nasal wall or maxillary sinus. They are most commonly seen in 40–70-year-olds with a male to female ratio of 2–4:1. CT demonstrates a soft-tissue mass centred in the middle meatus associated with bone remodelling. Stippled calcification is seen in 20% of cases. On MRI, it is isointense on T1WI and iso/hypointense on T2WI. Heterogeneous enhancement is seen in 50% of cases. A convoluted cerebriform pattern on T2WI or enhanced T1WI is typical of inverted papillomas.

Juvenile angiofibromas are seen in younger patients and are located in the posterior nasal cavity. They demonstrate intense enhancement and flow voids on MRI. Antrochoanal

polyps are homogeneously hyperintense on T2WI. Invasive fungal sinusitis is primarily seen in immunosuppressed patients. They are frequently bilateral. CT findings include complete opacification of sinuses by hyperdense mass, erosion or remodelling of sinuses, and intrasinus calcification. They are hypointense on T2WI. Nasal carcinomas cause bone erosion/destruction rather than remodelling.

Momeni A, Roberts C, and Chew F. Imaging of chronic and exotic sinonasal disease: self-assessment module. *American Journal of Roentgenology* 2007; 189: 546–548.

40. C. Medialization of middle turbinate.

FESS is the treatment of choice for patients with medically refractory sinusitis. Obstruction of the frontal recess is the main cause for medically refractory frontal sinusitis. The frontal recess is considered a difficult area to treat with FESS and it is also prone to re-stenosis.

All of the above options are commonly associated with postoperative frontal recess stenosis except medialization of middle turbinate. Medialization ('Boogerization') is performed to treat a lateralized middle turbinate, which is a well-recognized cause of frontal recess stenosis.

Huang B, Lloyd K, DeGaudio JM, Jablonsowski E, and Hudgins PA. Failed endoscopic sinus surgery: spectrum of CT findings in the frontal recess. *RadioGraphics* 2009; 29: 177–195.

41. A. No change in size, shape, or signal intensity on follow-up MRI.

Hypothalamic hamartomas are developmental malformations located in the tuber cinereum of the hypothalamus. The typical patient is male, in the first or second decade of life, presenting with precocious puberty or gelastic seizures.

On MRI, they appear as well-defined pedunculated or sessile lesions that are iso/mildly hypointense on T1WI and iso/hyperintense on T2WI, with no contrast enhancement or calcification. Lack of interval change strongly supports the diagnosis.

Saleem S, Ahmed-Hesham MS, and Lee DH. Lesions of the hypothalamus: MR imaging diagnostic features. *RadioGraphics* 2007; 27: 1807–1108.

42. B. II.

Lymph nodes in the neck have been divided into seven levels, generally for the purpose of squamous cell carcinoma staging. This is, however, not all inclusive, as the parotid nodes and retropharyngeal space nodes are not included in this system.

Level I: Below mylohyoid to hyoid bone anteriorly

Level Ia: Submental

Level Ib: Submandibular

Level II: Jugulodigastric (base of skull to hyoid)

Level III: Deep cervical (hyoid to cricoid)

Level IV: Virchow (cricoid to clavicle)

Level V: Posterior triangle groups

Level Va: Accessory spinal (posterior triangle), superior half

Level Vb: Accessory spinal (posterior triangle), inferior half

Level VI: Prearyngeal/pretracheal/Delphian node

Level VII: Superior mediastinal (between common carotid arteries (CCAs), below top of manubrium)

Lymph node levels of the neck. Radiopaedia.org.

43.A. Fibromatosis coli.

Fibromatosis coli or pseudotumour of the sternocleidomastoid muscle is a benign self-limiting condition that occurs in the first 2–4 weeks of life. It is often associated with breech or forceps delivery. It is thought to result from pressure necrosis and subsequent fibrocollagenous infiltration of the sternocleidomastoid muscle. Typical presentation is with a firm and non-tender mass in the lower two-thirds of the sternocleidomastoid muscle. It may be associated with torticollis in approximately 20% of cases. It usually resolves spontaneously in the first year of life. Typical findings on ultrasound include focal or diffuse enlargement of the sternocleidomastoid with variable echogenicity. The clinical history and ultrasound appearances are so typical that no further investigation is usually necessary. Ludwig B, Foster B, Saito N, Nadgir RN, Castro-Aragon I, and Sahai O. Diagnostic imaging in nontraumatic pediatric head and neck emergencies. *RadioGraphics* 2010; 30: 781–799.

44.B. Cavernous sinus.

Cranial nerves III, IV, and VI, and ophthalmic (V1) and maxillary (V2) divisions of the V cranial nerve course through the cavernous sinus along with the internal carotid artery. The V2 division of the trigeminal nerve passes through the inferior portion of the cavernous sinus and exits via the foramen rotundum. The remainder of the cranial nerves mentioned above enter the orbit via the superior orbital fissure. The cavernous sinus location accounts for these features. Palsies of cranial nerves III, IV, and VI result in ophthalmoplegia. Involvement of V1 and V2 divisions of the trigeminal nerve produces facial pain and sensory loss; involvement of sympathetic nerves around the internal carotid artery results in Horner's syndrome. This cluster of findings is found in Tolosa Hunt syndrome, an idiopathic inflammatory process involving the cavernous sinus. Hoang J, Eastwood J, and Glastonbury C. What's in a name? Eponyms in head and neck imaging. *Clinical Radiology* 2010; 65: 237–245.

45.E. Parotid space.

Loss of symmetry and displacement of the parathyroid space are useful for lesion identification and localization in the parathyroid soft tissues. A thorough knowledge of the anatomical relationship between the spaces is essential. The parathyroid space is shaped like an inverted pyramid with the apex pointing inferiorly toward the greater cornu of the hyoid bone and the skull base demarcates the base superiorly. A lesion arising from the parotid space displaces the fat in the parathyroid space anteromedially. A lesion in the masticator space displaces the parathyroid space posteriorly. Carotid space lesions displace it anteriorly, mucosal space lesions displace it posterolaterally, and retropharyngeal space lesions displace it anterolaterally. Posterior displacement of the carotid space or parathyroid space completely surrounding a lesion localizes it to the parathyroid space. Bahrami S and Yim C. Blind spots at brain imaging. *RadioGraphics* 2009; 29: 1877–1896.

46.B. Warthin tumours.

Warthin tumour or adenolymphoma is the second most common benign tumour of the parotid gland. It is usually solitary. Multiple or bilateral parotid masses and increased uptake on ^{99m}Tc are strongly suggestive of Warthin tumour. Warthin tumours do not enhance following gadolinium administration. Pleomorphic adenomas are usually solitary and unilateral. They appear as hypoechoic, lobulated, well-defined lesions with posterior acoustic enhancement on ultrasound scan (USS).

On MRI, they are of intermediate signal on T1WI and hyperintense on T2WI. They demonstrate homogeneous enhancement following gadolinium administration.

Mucocystic carcinomas vary in appearances. Low-grade tumours are similar to pleomorphic adenomas. High-grade tumours are heterogeneous with low to intermediate signal intensity on T1WI and T2WI. They demonstrate infiltrating margins and heterogeneous enhancement following gadolinium administration.

Soler R, Bargella A, Requejo I, Rodriguez E, Rey JL, and Sanclistan F. Pictorial review: MR imaging of parotid tumours. *Clinical Radiology* 1997; 52: 269–275.

Bialek EJ, Jakubowski W, Zajkowski P, Szopinski KT, and Osmolski A. US of the major salivary glands: anatomy and spatial relationships, pathologic conditions, and pitfalls. *Radiographics* 2006; 26: 745–763.

47. D. Splaying of the internal and external carotid arteries.

Carotid body tumour or paraganglioma is the most common paraganglioma of the head and neck. It arises from the paraganglionic cells located on the medial aspect of the carotid bifurcation. On MRI, they are of low to intermediate signal intensity on T1WI and hyperintense on T2WI. They are hypervascular and demonstrate intense enhancement after contrast administration. Splaying of the internal and external carotid arteries and multiple flow voids producing a 'salt and pepper' appearance are distinctive features on imaging.

Lee KY, Oh Y-W, Noh HJ, Lee YJ, Yong HS, and Kang EY. Extraadrenal paragangliomas of the body: imaging features. *American Journal of Roentgenology* 2006; 187: 492–504.

48. D. Eccentrically placed lesion in the cord. Table 6.2 illustrates the diagnostic features of astrocytoma and ependymoma.

Table 6.2 Diagnostic features of astrocytoma and ependymoma

Age	Children	Adults
Region	C > T > L	C > T = L
Location in cord	Eccentric	Central
Margins	Infiltrating	Sharp
Other findings	Long segment involved	Peripheral low T2WI signal
Associated syndrome	Neurofibromatosis-1	Neurofibromatosis-2

Smith JK, Lury K, and Castillo M. Imaging of spinal and spinal cord tumors. *Seminars in Roentgenology* 2006; 41: 274–293.

49. E. Meningioma.

Spinal meningiomas are typically iso- to hypointense on T1WI and slightly hyperintense on T2WI. There is usually strong and homogeneous enhancement with gadolinium. However, some meningiomas may contain calcification and are typically the only intradural extramedullary tumours to do so. Some meningiomas can be heavily calcified and such a meningioma is being described in the question. These will remain dark on all MRI sequences and demonstrate only little contrast uptake (in the non-calcified areas).

Schwannomas, neurofibromas, and metastases would not typically be hypointense on T2WI. Meningeal lymphomas are very rare and usually manifest as diffuse thickening of nerve roots and/or multiple enhancing nodules.

Abul-Kasim K, Thurner MM, McKeever P, and Sundgren PC. Intradural spinal tumours: current classification and MRI features. *Neuroradiology* 2008; 50: 301–314.

50. C. T2 fast SE.

T2 fast SE is probably the least useful sequence when specifically looking for vertebral marrow deposits because the metastases are less conspicuous, typically being high signal on a background of high-signal fatty marrow. On STIR and T2 fast SE with fat saturation, the metastases typically stand out as being of increased signal on a background of dark marrow because of the fat saturation techniques. On T1 fast SE sequences, the metastases typically stand out as being low signal on a background of high-signal fatty marrow.

Finally, T1 GE out-of-phase imaging is also good for looking for vertebral metastatic disease. This is a sequence with a specific echo time corresponding to the time it takes for water and fat protons to move exactly 180° out of phase. In the normal adult human, the medullary bone of the vertebral bodies contains approximately equal amounts of water and fat protons. In out-of-phase conditions, the signal of both will cancel out, leaving the vertebrae completely black. In the case of vertebral pathology, however, the signal will increase and, as such, vertebral metastases (or other lesions) will clearly stand out.

Van Goethem JWM, Van den Hauwe L, Ozsarak O, De Schepper AM, and Parizel PM. Spinal tumours. *European Journal of Radiology* 2004; 50: 159–176.

51. C. Le Fort fractures by definition refer to fractures involving the maxilla bilaterally.

Separation of all or a portion of the maxilla from the skull base is described as a Le Fort fracture. This can be unilateral when it is associated with sagittal or parasagittal fractures of the palate. Le Fort fractures by definition involve the posterior maxillary buttress at the junction of the posterior maxillary sinus and the pterygoid plates or through the posterior walls of the maxillary sinus. Once a pterygomaxillary disruption has been identified, the remaining facial buttresses are inspected to identify the type of Le Fort fracture. In Le Fort I fracture, the entire maxilla will move in relation to the rest of the face and skull. In Le Fort II fracture, there is complete craniofacial separation. Any combination of Le Fort I, II, and III can occur. Posterior extension of Le Fort fracture into the hard palate results in widening of the maxillary arch and dental malocclusion.

Hopper RA, Salemy S, and Sze RW. Diagnosis of midface fractures with CT: what the surgeon needs to know. *Radiographics* 2006; 26: 783–793.

52. B. Keratocystic odontogenic tumour.

These are benign but locally aggressive developmental tumours affecting adults in the second to fourth decades. They are most commonly located in the mandibular ramus and body, and are associated with an impacted tooth. They may be unilocular or multilocular and often contain daughter cysts extending into the surrounding bone. They can be associated with cortical expansion and erosion. They demonstrate minimal peripheral enhancement with contrast. The presence of multiple keratocystic odontogenic tumours raises the possibility of Gorlin basal cell nevus syndrome, which is an autosomal dominant disorder. Associated features include multiple basal cell carcinomas of the skin, mental retardation, midface hypoplasia, frontal bossing and prognathism, calcification of the falx and dura, and bifid ribs.

Devenney-Cahir B, Subramaniam RM, Reddy SM, Imsande H, Gohel A, and Sakai O. Cystic and cystic-appearing lesion of the mandible: Review. *American Journal of Roentgenology* 2001; 196: W566–W577.

53. A. Rathke cleft cyst.

These are benign cystic lesions of the pituitary fossa derived from the Rathke pouch. They are usually asymptomatic. Rathke cleft cysts are located in the midline between the anterior and posterior pituitary lobes and have a characteristic kidney shape on axial images. They are homogeneously hyperintense on T1WI, due to high protein concentration, and hypointense on T2WI, due to low intracystic water content. They do not enhance following contrast administration.

Absence of a fluid–fluid level is helpful in differentiating Rathke cleft cyst from hemorrhagic adenoma. Acute haemorrhage has heterogeneous signal on T2WI and may demonstrate thin peripheral enhancement on T1WI. Craniopharyngiomas have variable solid, cystic, and calcified components. They demonstrate heterogeneous enhancement following contrast. They may be intrasellar or suprasellar. A pseudo-fluid–fluid level may occasionally be seen in craniopharyngioma. Lipoma and cholesterol granuloma are hyperintense on both T1WI and T2WI.

Bonneville F, Cattin F, Marsot-Dupuch K, Dormont D, Bonneville J-F, and Chiras J. T1 signal hyperintensity in the sellar region: spectrum of findings. *Radiographics* 2006; 26: 93–113.

54. E. Second branchial cleft cyst.

The majority of branchial cleft anomalies arise from the second branchial cleft. The described findings are typical of a second branchial cleft cyst. Similar ultrasound appearances may be seen in a first branchial cleft cyst or a dermoid cyst. The anatomical location is the key to the diagnosis. Dermoid cysts are typically midline in location in the neck and first branchial cleft cysts are located in the region of parotid gland, external auditory canal, and angle of mandible. Lymphangiomas are typically located in the posterior triangle. On ultrasound, they appear multiloculated with intervening thin septa. Abscesses appear as ill-defined, irregular collections with thick walls and internal debris. Surrounding soft-tissue oedema, hyperaemia, and enlarged adjacent lymph nodes are also noted.

Wong KT, Lee YYP, King AD, and Ahuja AT. Imaging of cystic and cyst-like neck masses. *Clinical Radiology* 2008; 63: 613–622.

55. D. Filling of retropharyngeal space from side to side.

Understanding the retropharyngeal space anatomy is crucial in differentiating retropharyngeal space abscess and retropharyngeal lymph node. The retropharyngeal space is bounded by visceral fascia covering the pharynx and oesophagus anteriorly, the prevertebral fascia covering the prevertebral muscles posteriorly, and the carotid sheaths laterally. A retropharyngeal lymph node is unilateral, whereas a retropharyngeal abscess fills the entire retropharyngeal space from side to side. The differentiation is important because many cases of suppurative lymph nodes do not have purulent material at surgery. The treatment for suppurative lymph nodes is a trial of antibiotics if the patient is stable. Surgical drainage is considered if there is progression or if the suppurative lymph node is large at presentation. The volume of central low density is a better predictor of purulence than the mere presence of rim enhancement and low-density centre.

Hoang JK, Branstetter IV BF, Eastwood JD, and Glastonbury CM. Multiphasic CT and MRI of collections in the retropharyngeal space: is it an abscess? *American Journal of Roentgenology* 2011; 196: W426–W432.

56. B. Neurosarcoïd.

Whilst primary neurosarcoïd is rare, it is not uncommon for the systemic disease to present via its neurological manifestations. The findings of neurosarcoïd are non-specific, with the common manifestations mirroring those described in this patient. Leptomeningeal thickening and enhancement are classical. Involvement of the perivascular spaces adjacent to this can cause increased signal in the adjacent cortex. This appearance can mimic meningioma.

Multifocal meningiomas and nerve sheath schwannomas are features of NF-2, but this would not be expected to resolve with steroid therapy. The features described are not typical of TS. The meningeal disease would make MS unlikely, even given the periventricular high-signal lesions, which are the most common intraparenchymal finding in neurosarcoïd.

Sarcoïd involving the skull table is not directly related to the neurosarcoïd and is more commonly seen with other manifestations of musculoskeletal sarcoïd.

Toxoplasmosis, in the absence of immunocompromise, is unlikely. Overall the response to steroid, along with the wide variation of CNS disease described, are the strongest indicators for sarcoïd. Whilst neurosarcoïd does typically respond well to steroid therapy, it has a high recurrence rate.

Lury K, Smith K, Mathews M, and Castillo M. Neurosarcoïdosis – review of imaging findings. *Seminars in Roentgenology* 2004; 39(4): 495–504.

57. B. Multisystem atrophy (MSA).

T2WI cruciform hyperintensity or the 'hot cross bun' sign within the pons, is suggestive of MSA, although it is not specific, as it also occurs in spinocerebellar ataxia. Other MRI features include hyperintensity within the putamen. Patients with MSA typically have parkinsonian features poorly responsive to levodopa therapy and autonomic disturbance. MRI features of Parkinson's disease are generally non-specific, but narrowing of the pars compacta of the substantia nigra may be seen on T2WI. Substantia nigra atrophy is also a feature of Lewy body dementia. T2WI hypointensity of the putamen due to iron deposition is a feature of progressive supranuclear

palsy. Gilman S, Wenning GK, Low PA, Brooks DJ, Mathias CJ, and Trojanowski JQ. Second consensus statement on the diagnosis of multiple system atrophy. *Neurology* 2008; 71(9): 670–676.

58. C. Marchiafava–Bignami disease.

This is a rare complication of chronic alcohol consumption characterized by demyelination and necrosis of the corpus callosum, although other white matter tracts (such as the external capsule) may be involved. Bilateral and symmetrical T2WI hyperintensities within the thalami, periaqueductal grey, and mammillary bodies are seen in Wernicke's encephalopathy. Osmotic myelinolysis is usually secondary to rapid changes in serum sodium and results in increased T2WI signal within the central pons. Extrapoline myelinolysis is rare. In alcohol withdrawal syndrome, patients present with seizures and delirium tremens. MRI may show volume loss in the temporal cortex and anterior hippocampus. Hepatic encephalopathy secondary to hepatocellular failure may produce T1WI hyperintensity within the caudate nucleus, globus pallidus, putamen, and anterior midbrain due to increased concentration of manganese.

Geibprasert S, Gallucci M, and Krings T. Alcohol induced changes in the brain as assessed by MRI and CT. *European Radiology* 2010; 20: 1492–1501.

59.A. Decreased CBF/decreased CBV/increased MTT.

In identifying the ischaemic penumbra, CT perfusion offers promise in improved patient selection for thrombolysis beyond a rigid time window, in the infarct core (tissue which is not salvageable) both CBF and CBV are decreased with a corresponding increase in MTT. Penumbra tissue (which is potentially recoverable by thrombolysis) exhibits a CBF/CBV mismatch with an increased CBV, but decreased CBF (and increased MTT). An increase in CBF and CBV with decreased MTT is a feature noticed in tumours secondary to angiogenesis and microvascular permeability. Hoefner EG, Case I, Jain R, Gujar SK, Shah GV, Develis JP et al. Cerebral perfusion CT: technique and clinical applications. *Radiology* 2004; 231: 632–644.

60.A. MS.

The key feature in this clinical vignette is the identification of the mass lesion crossing the midline. Only a few lesions demonstrate this ability and they are GBM, lymphoma, metastases, MS and other white matter disorders, lipoma, stroke, and shearing injuries. Abscess is thus excluded and would be unlikely given the clinical features. GBM is unlikely given the absence of necrosis and would be rare in a patient of this age group. High-grade astrocytomas do not involve the corpus callosum and cross the midline. Lymphoma exhibiting these features would be uncommon in immunocompetent patients, being more typically associated with HIV-related lymphoma. Tumefactive MS typically presents with an acute clinical history and frequently displays the imaging features described. The presence of vascular structures crossing the lesion also indicates this diagnosis, as these would be displaced by neoplastic lesions.

Grossman R and Yousem D. *Neuroradiology: The Requisites*, 2nd edn, Mosby, 2003, pp. 139–145, 153–155.

61.D. Straight sinus.

Pregnancy is a risk factor for both venous sinus thrombosis and hypertensive haemorrhage secondary to eclampsia. Hyperattenuating thrombus within the occluded sinus is classical on the unenhanced CT, but is seen in only 25% of cases. On the contrast-enhanced study, a central filling defect surrounded by enhancing dura (empty delta sign) is present in over 30%. Most of the superior cerebrum is drained by the superior sagittal sinus. The transverse sinuses receive blood from the temporal, parietal, and occipital lobes. The transverse sinuses drain into the sigmoid sinuses and on into the internal jugular veins. The straight sinus forms from the confluence of the inferior sagittal sinus and vein of Galen. The vein of Galen is part of the deep venous system, which drains the corpus callosum, basal ganglia, thalamus, and upper brainstem. Cavernous sinus thrombosis presents with proptosis and cranial nerve palsies (usually cranial nerve VI first). The cavernous sinus receives the petrosal sinuses and middle cerebral veins.

Leach JL, Fortuna RB, Jones BV, and Gaskill-Shiple MF. Imaging of cerebral venous thrombosis: current techniques, spectrum of findings and diagnostic pitfalls. *Radiographics* 2006; 26: S19–S41.

62.A. Early venous drainage.

Brain AVMs are abnormal connections between arteries that would normally supply the brain tissue and veins that normally drain the brain, resulting in shunting with an intervening network of vessels within the brain parenchyma. The finding of early venous drainage is important in differentiating brain AVMs from other vascular lesions. Cortical venous drainage may be seen in superficial lesions. Recruitment of transdural supply is observed in large lesions, although this is a more typical feature of proliferative angiodysplasia, which is a diffuse type of AVM. Classically, in this condition, normal brain parenchyma is interspersed between the abnormal vessels. Stenoses of feeder vessels are also often identified in proliferative angiodysplasia. The caput medusae of dilated medullary veins is a feature of DVAs, a normal variant. Dilated cortical veins are seen in dural

arteriovenous fistulas (DAVFs), which are abnormal connections between arteries that normally supply the meninges (but not the brain) and small venules within the dura.

Gelbraser S, Pongpech S, Jarakongmun P, Shroff MM, Armstrong DC, and Krings T. Radiologic assessment of brain arteriovenous malformations: what clinicians need to know. *Radiographics* 2010; 30: 483–501.

63. E. Association with vomiting.

Headache accounts for approximately 2% of all A&E department visits, yet subarachnoid haemorrhage accounts for less than 3% of these headaches. Up to half of all patients with subarachnoid haemorrhage, however, will be alert and neurologically intact. A recent study prospectively assessed neurologically intact patients presenting with headache peaking within 1 hour to determine which variables are predictive of subarachnoid haemorrhage. High-risk variables include age >40, neck pain, witnessed loss of consciousness, onset with exertion (but not sexual activity), arrival by ambulance, vomiting, and blood pressure >160/100 mmHg. The presence of one or more of these findings in a patient with an acute non-traumatic headache reaching maximum intensity within 1 hour should prompt further investigation.

Perry JJ, Stiell IG, Sivilotti MLA, Bullard MJ, Lee JS, Eisenhauer M et al. High risk clinical characteristics for subarachnoid haemorrhage in patients with acute headache: prospective cohort study. *British Medical Journal* 2010; 341: c5204.

64. C. Cavernous malformation (cavernoma).

This is a benign vascular hamartoma, which can occur anywhere throughout the CNS, although spinal cord involvement is rare. It is typically a discrete, lobulated mass <4 cm containing blood products at different stages of evolution. On MRI they are described as having a 'popcorn' appearance of mixed signal intensity with a hypointense haemosiderin rim. They display little to no enhancement. Prominent susceptibility effect on T2* GE is typical. AVMs will demonstrate multiple flow voids. Haemorrhagic neoplasms will exhibit strong enhancement and an incomplete haemosiderin rim. Multiple 'black dots' are a feature of amyloid angiopathy. Capillary telangiectasias are poorly demarcated lesions, usually <1 cm, demonstrating 'brush-like' enhancement on T1WI post contrast. They are not usually identified on CT.

Osborn AG, Blaser SI, Salzman KL, Katzman GL, Provenzale J, Castillo M et al. *Diagnostic Imaging: Brain*. Amirsys, 2004, 1-5: 24–27.

65. C. Catheter angiography.

Perimesencephalic haemorrhage is confined to the cisterns around the midbrain. In some cases the only blood is found anterior to the pons. Some sedimentation into the lateral ventricles may occur but frank haemorrhage into the ventricles and/or extension into the sylvian fissure or anterior interhemispheric fissure (as in this case) indicates arterial haemorrhage. Catheter angiography following a negative CTA in the setting of a perimesencephalic bleed arguably does not have any extra diagnostic yield. However, catheter angiography remains the gold standard for detecting aneurysms, and in this case an anterior communicating artery aneurysm requires exclusion.

Van Gijn J and Rinkel GJE. Subarachnoid haemorrhage: diagnosis, causes and management. *Brain* 2001; 124: 249–278.

66. C. DWI.

The sensitivity and specificity of DWI in detecting acute ischaemia are 88–100% and 86–100%, respectively, and DWI is established as better than other conventional MRI techniques. In addition, acute from chronic ischaemia can be differentiated. DWI is a measure of the Brownian motion of water molecules within a tissue. Two sets of images are acquired; the DWI and the

quantitative ADC map. Chronic lesions may appear bright on the DWI (T2 shine through), but only acute lesions with restricted diffusion will be dark on the ADC map. It should be noted, however, that high signal intensity on DWI with low ADC has been reported in a variety of conditions such as abscess, lymphoma, and gliomas. GE is useful for identifying microbleeds that may influence antithrombotic treatment.

Wallis A and Saunders T. Imaging transient ischaemic attack with diffusion weighted magnetic resonance imaging. *British Medical Journal* 2010; 340: c2215.

67.D. Optic nerve glioma.

NF-1 is an autosomal dominant neurocutaneous disorder. The gene locus is located on 17q11.2. Diagnosis of NF-1 requires two or more of the following: six or more café-au-lait spots, two or more neurofibromas (or one plexiform neurofibroma), axillary/inguinal freckling, optic nerve glioma, sphenoid wing dysplasia or a first-degree relative with NF-1. The classic imaging appearance is multiple focal areas of white matter and deep gray matter signal abnormality. Other potential findings include intracranial stenoses and moyamoya type proliferation. NF-2 characteristically presents with multiple intracranial schwannomas, meningiomas and ependymomas (MISME). Bilateral vestibular schwannomas is diagnostic of NF-2.

Osborn AG, Blaser SI, Salzman KL, Katzman GL, Provenzale J, Castillo M et al. *Diagnostic Imaging: Brain*, Amirsys, 2004, 1-1: 78-85.

68.A. Porencephalic cyst.

Porencephaly is a congenital/acquired cystic cavity within the brain parenchyma with adjacent enlargement of the lateral ventricle. They develop *in utero* or early infancy. Arachnoid cysts are also CSF isointense, but are extra-axial, displacing the brain away from the adjacent skull. Ependymal cysts are intraventricular and the surrounding brain is usually normal. Schizencephaly is characterized by an intraparenchymal cleft extending from the ventricular surface to the brain surface lined by gray matter. Hydranencephaly results from an early destructive process of the developing brain. The cranial vault is CSF filled with absence of the cortical mantle and ventricles (water-bag brain). Death in infancy is typical.

Osborn AG, Blaser SI, Salzman KL, Katzman GL, Provenzale J, Castillo M et al. *Diagnostic Imaging: Brain*, Amirsys, 2004, 1-7: 36-39.

69.E. Normal calcium-phosphorus metabolism.

Fahr disease is a rare degenerative neurological disorder characterized by extensive bilateral basal ganglia calcifications that can lead to progressive dystonia, parkinsonism, and neuropsychiatric manifestations. CT has higher diagnostic specificity for basal ganglia calcification over MRI. The distribution of calcifications is similar in endocrinological disorders such as hyperparathyroidism, hypoparathyroidism, and pseudohypoparathyroidism. The calcium-phosphorus metabolism is usually normal in Fahr disease. In pseudohypoparathyroidism the serum calcium is low with an appropriately high parathyroid hormone (PTH), due to PTH resistance.

Osborn AG, Blaser SI, Salzman KL, Katzman GL, Provenzale J, Castillo M et al. *Diagnostic Imaging: Brain*, Amirsys, 2004, 1-10: 16-19.

70.C. Posterior reversible encephalopathy syndrome (PRES).

This is a disorder of cerebrovascular autoregulation and is associated with eclampsia, which is defined clinically as seizure or coma with pregnancy-induced hypertension. There is a predilection for the posterior circulation and watershed zones, possibly due to its sparse vasomotor sympathetic innervation. T2WI hyperintense lesions within the posterior cortex and subcortical white matter, without diffusion restriction, are typical. Diffusion restriction/low ADC will be

found in infarction. The diagnosis of postpartum cerebral angiodopathy should be considered in normotensive postpartum women presenting with intracerebral haemorrhage. Reversible high T2WI signal abnormalities may also be seen in the cortex and subcortical white matter. Multifocal stenoses and beading of the intracranial vasculature are also a feature. PML presents with asymmetrical T2WI hyperintensity in the periventricular and subcortical white matter, with cortical sparing. It is seen in the immunocompromised. Gliomatosis cerebri is a diffusely infiltrating tumour involving two or more lobes and is frequently bilateral. Enlargement of the involved structures is seen. It can mimic brainstem PRES.

Zak IT, Duai HS, and Kish KK. Imaging of neurologic disorders associated with pregnancy and the postpartum period. *Radiographics* 2007; 27: 95–108.

Osborn AG, Blaser SI, Salzman KL, Katzman GL, Provenzale J, Castillo M et al. *Diagnostic Imaging: Brain*, Amirsys, 2004, 1-10: 28–31.

71.D. Funnel-shaped aqueduct

Aqueductal stenosis is a focal reduction in aqueduct size, which can be congenital or acquired. Stenosis occurs at the level of the superior colliculi or at the intercollicular sulcus. The best diagnostic clue is a funnel-shaped aqueduct. There is resultant ballooning of the lateral and third ventricles. The fourth ventricle is normal distal to the obstruction. The most specific finding is lack of CSF flow through the aqueduct on phase contrast MRI. Other findings include thinning of the corpus callosum and downward displacement of the internal cerebral veins and third ventricular floor. In older patients it can present similarly to NPH. Imaging findings in NPH include ventriculomegaly (with relative sparing of the fourth ventricle) out of proportion to sulcal enlargement, with normal hippocampal. The aqueductal 'flow-void' sign reflects increased CSF velocity through the aqueduct, although this can be observed in normal individuals.

Osborn AG, Blaser SI, Salzman KL, Katzman GL, Provenzale J, Castillo M et al. *Diagnostic Imaging: Brain*, Amirsys, 2004, 11-1: 20–27.

72.C. Does not extend anterior to the foramen of Monro.

Cavum septum pellucidum (CSP), cavum vergae (CV), and cavum velum interpositum (CVI) are all considered normal variants, although CSP is possibly more prevalent in boxers due to repeated head trauma, most famously referred to in Rocky V. CSP is universal in fetuses, but decreases with age. CSP is an elongated finger-shaped CSF collection between the frontal horns of the lateral ventricles. Posterior extension between the fornices is referred to as CV. CV almost never occurs in the absence of CSP. CVI, however, is a triangular-shaped CSF space between the lateral ventricles that does not extend anterior to the foramen of Monro. Absent septum pellucidum can look like CSP/CV on sagittal imaging. It is commonly associated with other congenital anomalies.

Osborn AG, Blaser SI, Salzman KL, Katzman GL, Provenzale J, Castillo M et al. *Diagnostic Imaging: Brain*, Amirsys, 2004, 11-1: 8–11.

73.B. Lactate peak on MR spectroscopy.

Neuroepithelial tumours are either low grade (WHO I and II) or high grade (WHO III and IV). The classification relies on pathology, but as this requires brain biopsy it is not without significant risk. Advanced MRI techniques play an increasing role in helping to differentiate these lesions, as low-grade lesions may be managed via a 'watch and wait' approach. Conventional MRI is poorly sensitive for glioma grading, as low-grade gliomas can enhance (in up to 20%) and up to 30% of non-enhancing gliomas are malignant. MR perfusion can help differentiate, as rCBV tends to increase with tumour grade. A threshold of 1.75 is commonly utilized to separate low- from high-grade gliomas, but low-grade oligodendrogliomas can give misleadingly elevated rCBV values. The classic MR spectroscopy features of high-grade lesions are elevated choline and reduced NAA.

In addition an elevated lactate signal is typical of high-grade lesions secondary to the anaerobic environment. ADC is usually lower in high-grade lesions, but there is considerable overlap and so ADC maps are insufficient on their own for predicting tumour grade.

Al-Okailli RN, Krejza J, Wang S, Woo JH, and Melhem ER. Advanced MR imaging techniques in the diagnosis of intraxial brain tumors in adults. *Radiographics* 2006; 26: S173–S189.

Law M, Yang S, Wang H, Babb JS, Johnson G, Cha S et al. Glioma grading: sensitivity, specificity and predictive values of perfusion MR imaging and proton MR spectroscopic imaging compared with conventional MR imaging. *American Journal of Neuroradiology* 2003; 24: 1989–1998.

74.B. Erosion of the adjacent porus acusticus.

A large meningioma at the cerebellopontine angle can easily grow into the adjacent internal auditory meatus (IAM), but typically does so without causing any enlargement or erosion of this structure. Most vestibular schwannomas arise from the inferior vestibular nerve within the IAM and as they grow they smoothly erode the posterior edge of the porus acusticus.

Although dural enhancement has been described adjacent to vestibular schwannomas, an enhancing 'dural tail' would be a finding more commonly associated with a lesion arising from the dura, typically a meningioma.

Bony hyperostosis is a finding that is associated with meningioma. Both meningiomas and vestibular schwannomas typically show avid enhancement with intravenous gadolinium.

Bonneville F, Savatovsky J, and Chiras J. Imaging of cerebellopontine angle lesions: an update. Part 1: enhancing extra-axial lesions. *European Radiology* 2007; 17: 2472–2482.

75.C. Loss of the posterior pituitary bright spot.

Autoimmune hypophysitis (AH) and non-secreting pituitary adenomas can only be differentiated with certainty on histology. As a result, approximately 40% of patients with AH are misdiagnosed as having pituitary macroadenoma and undergo unnecessary surgery. Hormone production is compromised in both conditions, although a history of infertility is common with adenomas, whereas patients with AH typically achieve spontaneous pregnancy. In an attempt to develop a scoring system to differentiate the two conditions, a recent study found that features significantly associated with AH over adenoma were age < 30, relation to pregnancy, homogeneous gadolinium enhancement, loss of the posterior pituitary bright spot, and enlarged stalk. Features consistent with adenoma were asymmetrically enlarged pituitary, size > 6 cm³, and associated sinus mucosal thickening. The normal posterior pituitary gland is bright on T1WI due to the rich content of vasopressin neurosecretory granules. This is frequently lost in AH due to direct autoimmune involvement of the neurohypophysis, whereas it is conserved in the majority of adenomas, even when displaced by large tumour size.

Gutenbergh A, Larsen J, Lupi I, Rohde V, and Caturegli P. A radiologic score to distinguish autoimmune hypophysitis from nonsecreting pituitary adenoma preoperatively. *American Journal of Neuroradiology* 2009; 30: 1751–1753.

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